ISSN 0377-9335

ENTOMON

Vol. 14 June 1989 No. 1 & 2

CONTENTS

(*Continued on cover page* 4)

ASSOCIATION FOR
ADVANCEMENT OF ENTOMOLOGY
DEPARTMENT OF ZOOLOGY, UNIVERSITY OF KERALA
KARIAVATTOM, TRIVANDRUM, INDIA 695 581

ENTOMON

Entomon is a quarterly journal of the Association for Advancement of Entomology issued in March, June, September and December, devoted to publication of research work on various aspects of insects and other land arthropods.

Address MS and all editorial correspondence to Managing Editor, *Entomon*, Department of Zoology, University of Kerala, Kariavattom, Trivandrum, India 695 581.

SUBSCRIPTION RATES

Annual Subscription for	institutions:	Rs 150/-(in India);	$ 50 (abroad, air mail)
,, ,,	individuals:	Rs 50/- ,,	$ 20/- (,, sea mail)

1. **All remittance to the Journal or Association should be sent to the Secretary-Treasurer of the Association by bank braft only, A/c payee in favour of the Association for Advancement of Entomology.**
2. **Requests for replacement copies of ENTOMON in lieu of numbers lost in transit, should reach the Secretary-Treasurer not later than three months after the date of publication of the number.**

ENTOMON is covered in the following abstracting/indexing journals : *Chemical Abstracts, Review of Applied Entomology, Science Citation Index* and *Current Contents/Agriculture, Biology & Environmental Sciences, Biological Abstracts, Entomology Abstracts* and other relevant *Abstracts, Referativny Zhurnal* and *Current Advance in Biological Sciences.*

Entomon 1989 Vol. 14 No. 1 & 2 pp. 1 to 9

SPERMATOGENESIS IN *SPODOPTERA LITURA* (LEPIDOPTERA: NOCTUIDAE)

R. SRIDEVI, APARNA DUTTA-GUPTA (RAY) & P. S. RAMAMURTY[1]
School of Life Sciences, University of Hyderabad, Hyderabad, India 500134

(*Received* 4 *September* 1988)

In the larval stages the testis of *Spodoptera litura* are paired structures, having four follicles in each testis. They fuse into a single median testis in the prepupal stage. Squash preparations of the testes examined under phase optics, reveal that secondary spermatocytes begin maturation and elongation in the mid-last larval instar. Spermatocytes within a spermatocyst divide synchronously and sperm in various stages of development can be seen in both the pupal and adult testis. Apical cell surrounded by spermatogonial cells has been observed in the testis of penultimate instars. Each elongating spermatocyst is associated with a single nutritive cell. Atretic spermatocysts have also been observed. Residual bodies are localised in the interfollicular septa.

(*Key words:* spermatogenesis, testes, *Spodoptera*)

INTRODUCTION

Spermatogenesis provides a useful model system to study the profound morphological changes that take place during the terminal differentiation of a cell. The internal reproductive system of the male, including the testes have been studied in varying degrees of detail in many orders of insects (PHILLIPS, 1970; ROOSEN-RUNGE, 1977) including Leipdoptera (FATZINGER, 1970; OUTRAM, 1971; FERRO & AKRE, 1975; DONG *et al.*, 1980; MISKIMEN *et al.*, 1983). Notwithstanding these studies, relatively little attention has been paid to gametogenesis in the male insect as compared to similar events in the female. The present investigation deals with spermatogenesis in the tobacco moth *Spodoptera litura,* which revealed certain special histological features and attention is focussed on them in the present report.

[1] Author for correspondence.

MATERIALS AND METHODS

Insect rearing:

The insects were reared in a culture room at 26±1°C, 14 : 10 light dark period and 70% relative humidity on an artificial diet, according to NAGARKATTI & PRAKASH (1974). The larvae were maintained individually in autoclaved glass tubes and checked at regular intervals for infection. The pupae were maintained in glass troughs on a piece of moistened sponge for adult emergence. Adults were maintained in dark cages on 25% honey enriched with yeast and vitamin E.

Phase contrast studies of spermatogenesis:

Testes of insects from various stages of development were dissected out in insect Ringer on a glass slide and teased to liberate the cysts. A cover slip was placed over the cysts and studied under a phase contrast microscope.

Histological and histochemical studies:

The testes were dissected out in insect Ringer and fixed in Bouin's fluid. Paraffin sections were cut at 6 μm and stained either with Heidenhain's iron alum-haematoxylin eosin, or with bromphenol blue.

RESULTS

Morphology of testes:

The internal reproductive system in the male of *Spodoptera litura,* consists of a pair of fused testes, paired vas deferens, accessory reporductive glands and a common median ejaculatory duct. In the larval stages, the testes are distinctly paired, kidney-shaped bodies situated between the 5th and 6th abdominal segments dorsolateral to the alimentary canal. During the prepupal stage the paired testes move towards the dorso-median line and fuse together, to give rise to a single spherical testis present in the pupal and adult stages. The testis is richly supplied with tracheal network.

Histology of the testis:

During the larval stages, each of the lateral testicular lobes is made up of four, follicles (Fig.1). The testicular lobes are enclosed within two thick, double–layered peritoneal sheaths. Each of these sheaths is composed of two layers of epithelial cells. The external sheath is made up of lightly stained cuboidal cells resting on a basement membrane. This forms a common envelope to all the follicles of a testis and is penetrated by tracheal branches. The inner sheath is made up of more darkly stained elliptical cells within which muscle fibres are distinguishable (Fig. 2.). Ingrowths from this sheath in the form of double-walled septa penetrate between the follicles so as to separate them from one another. Each testicular follicle opens into a vas efferens. The four vasa efferentia converge at the hilum (Figs.1, 3) and open into a common vas deferens. The spermatocysts within a follicle develop centripetally, that means, the immature cysts are arranged towards the periphery of the enlarged end of the follicle (Fig. 1). In a cross section of the testes one can see a large number of degenerating spermatocysts interspersed among the developing healthy spermatocysts. They can be distinguished from the neighbouring normal spermatocysts by their greater intensity of staining with heamatoxylin-eosin (Fig. 4) and bromphenol blue (Fig. 5). They also exhibit a more compact appearance.

Spermatogenesis:

Squash preparations and histological studies of the early larval testes reveal the presence of a large number of spermatogonial cells near the outer border of the follicles. These spermatogonial cells are arranged concentrically around a large apical cell with a prominent nucleus bearing two nucleoli (Fig. 6). There is a preponderance of spermatocysts containing primary spermatocytes during the penultimate and early last instar larvae (Fig. 7). The cells within a spermatocyst tend to divide synchronously (Fig. 8). Secondary spermatocytes are noticeable in the early last instars (Fig. 8) and they persist through the mid last (Fig. 9), late last instars as well as in the prepupae (Fig. 10). These begin to differentiate into the spermatids from the mid last instar onwards (Fig. 9). In the process of maturation and elongation of spermatids, the spermatocysts assume an elliptical shape (Fig. 11). The sperm bundles formed as a result of maturation of the spermatids are seen abundantly in the adult stages (Fig. 12). Spermiogenesis is however not synchronous and spermatozoa in various stages of differentiation are detectable in the freshly emerged adult testes.

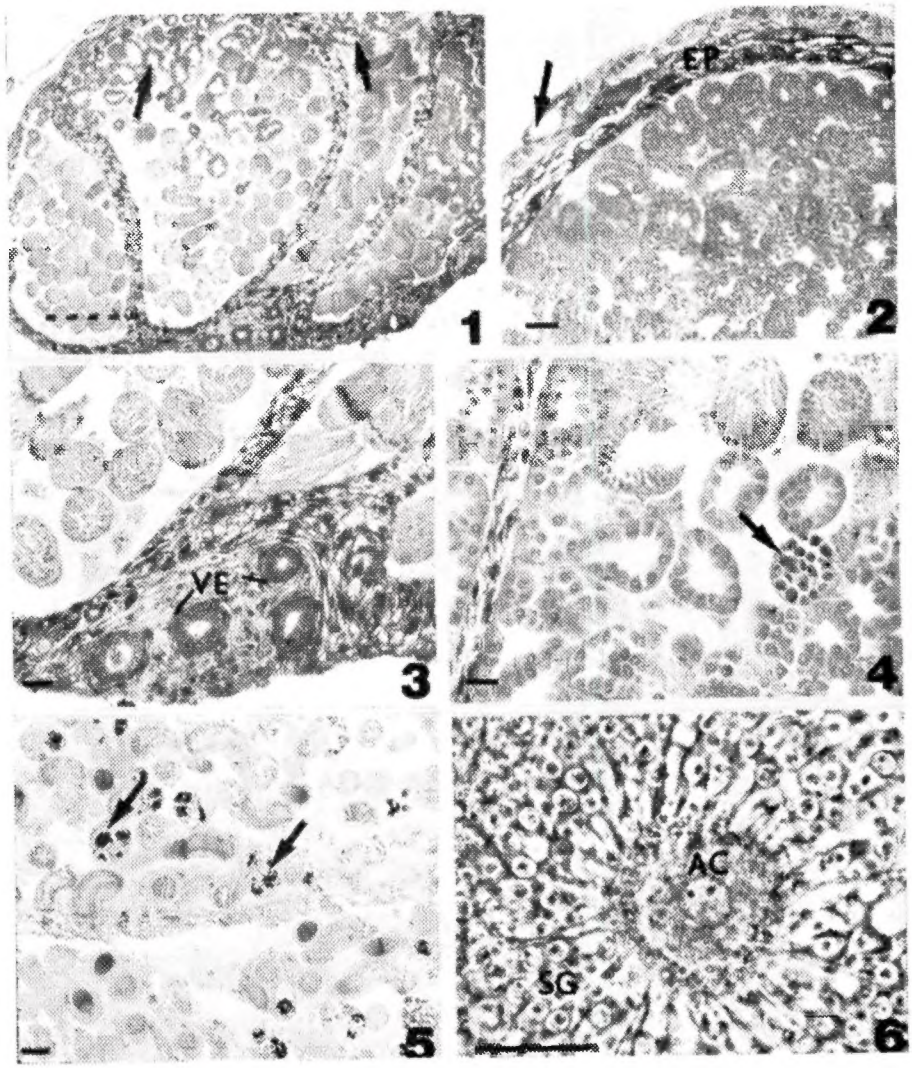


Fig. 1. Section through the testis of late last instar showing the four follicles. Note the presence of germ cells in early stages of development near the outer brder (→) of the follicles while the more mature stages occur towards the narrow part of the folllicle. Bouin/Haematoxylin-Eosin (HE).

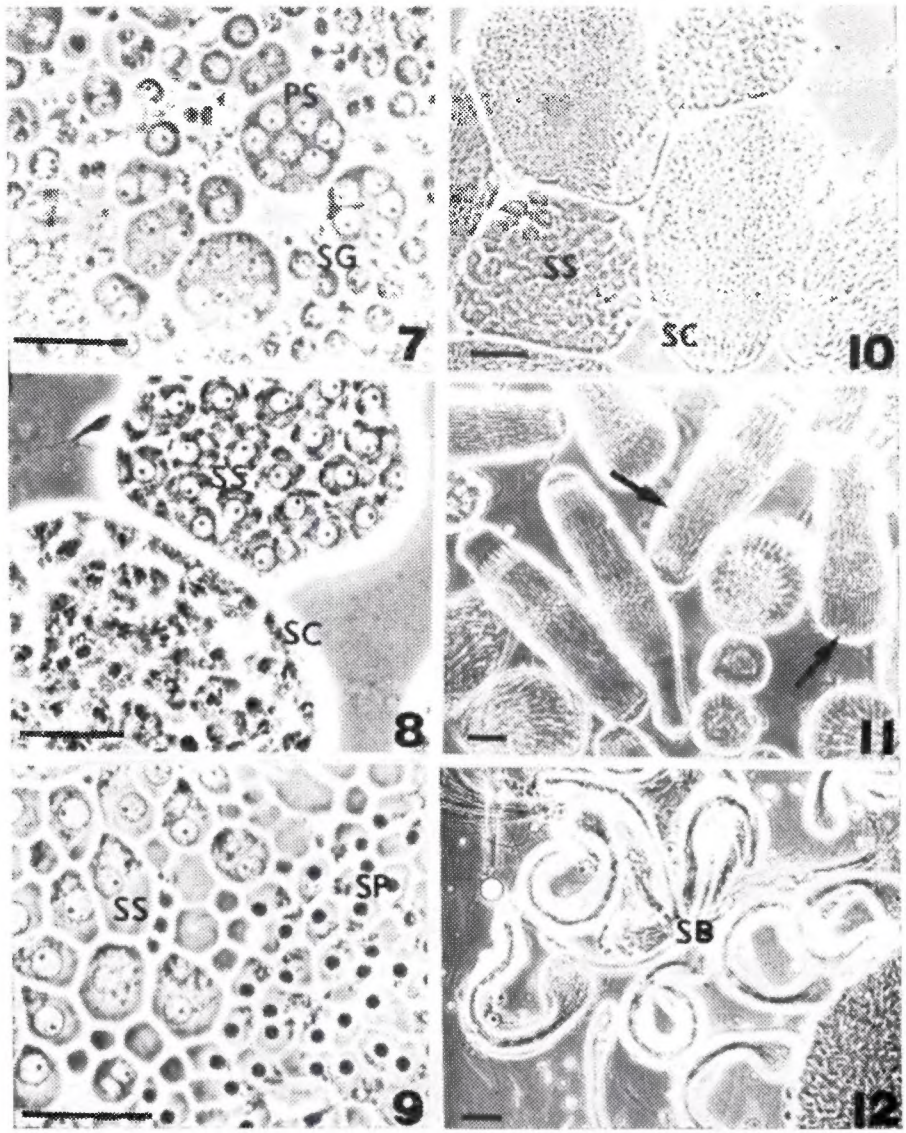
Fig. 2. Section of the testis of late last instar showng the two peritoneal sheaths, each consisting of double layers of epithelial cells (EP). The external layer, penetrated by tracheal network (→) forms a common envelope to all the follicles. The inner, more darkly stained layer with intracellular muscle fibres, forms septa separating the follicles from one another. Bouin/HE.

Fig. 3. A section of late last instar testes showing the vas efferens (VE) of the four follicles converging at the hilum of the testis. Bouin/HE.

Fig. 4. Illustrates a degenerating spermatocyst (→) in the testis of late last instar larvae. Note its relatively intense staining with haematoxylin-eosin, as compared to the rest of the healthy spermatocysts.

Fig. 5. Shows numerous degenerating speramatocysts (→) in old adult testes and the strong positive reaction they give for protein. Bouin/BPB.

Fig. 6. Phase contrast photomicrograph showing the presence of an apical cell (AC) surrounded by large number of spermatogonial cells (SG) in the testes of penultimate instar.



Figs. 7–11. Unstained phase contrast photomicrographs of spermatocysts liberated from the testicular follicles by teasing the peritoneal coverings.

Fig. 7. Shows the preponderance of primary spermatocytes (PS) in the testicular follicles of penultimate larval instar. Note the presence of a large nucleus surrounded by a thin layer of cytoplasm in these cells. SG = spermatogonial cells.

Fig. 8. Shows secondary spermatocytes (SS) released from early last larval testes. Note the synchronous division of spermatocytes within a spermatocyst (SC).

Fig. 9. Shows numerous secondary spermatocytes (SS) and spermatids (SP) liberated from the spermatocysts of testicular follicles of mid last larval instar.

Fig. 10. Shows secondary spermatocytes (SS) and elongating spermatocysts (SC) of prepupal testis.

Fig. 11. Shows in the late prepupal stage, the elongating cysts (→) which gives rise to eupyrene sperm bundles.

Fig. 12. Shows eupyrene sperm bundles (SB) present in the testes of old adults.

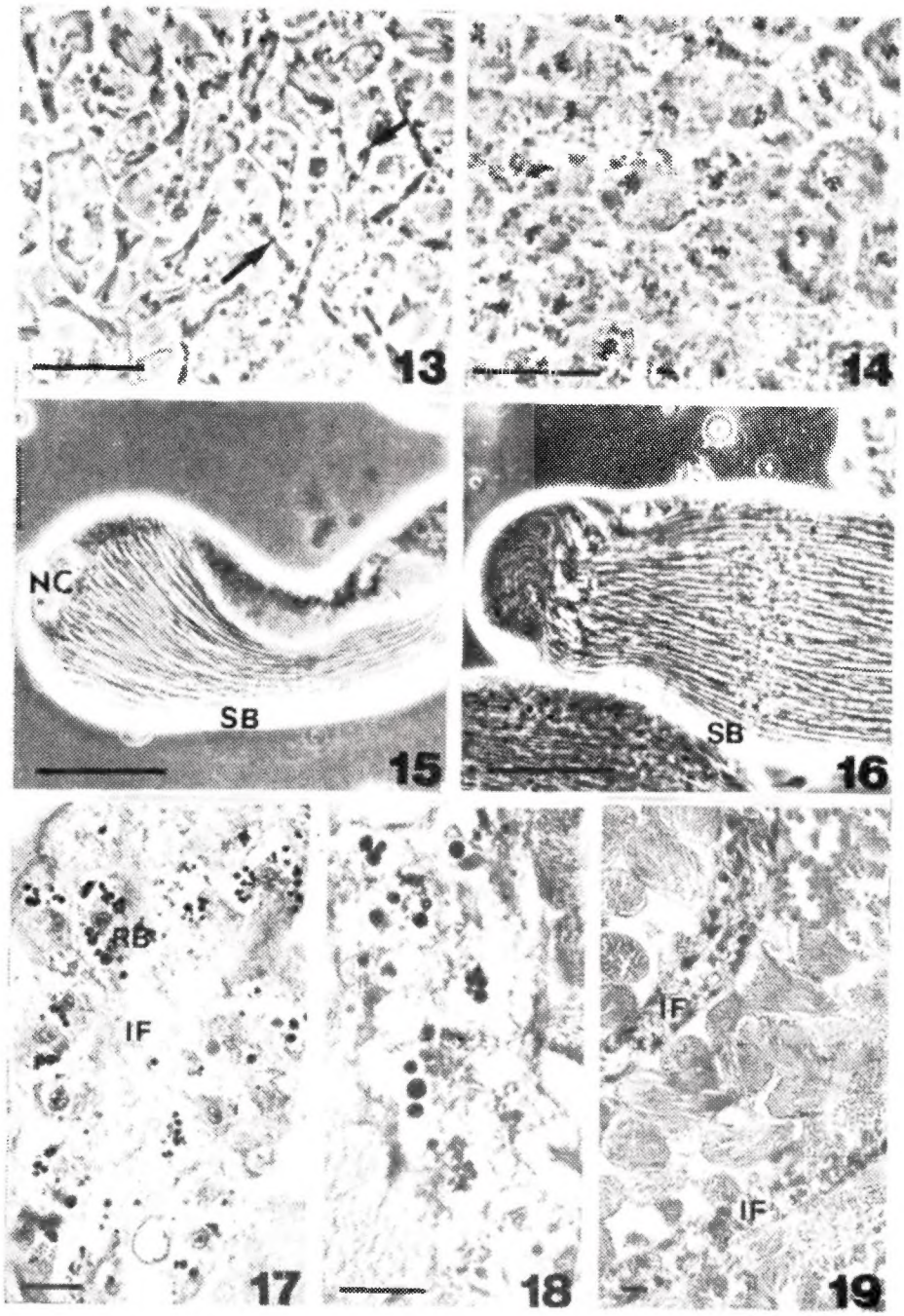


Fig. 13. Phase contrast photomicrograph of metaphase - telophase chromosomes of apyrene spermatocytes. Note the characteristic interconnections between the daughter nuclei (—). Compare with Fig. 14. showing eupyrene metaphase of the same stage.

Fig. 14. Phase contrast photograph of eupyrene metaphase of the same stage as that of Fig. 13.

Fig. 15 Phase contrast picture of nutritive cell (NC) associated with the sperm bundles (SB).

Fig. 16. Shows parallel alignment of spermatozoa within a sperm bundle (SB), forming a compact unit.

Fig. 17. Shows the residual bodies (RB) localised within the cells of the interfollicular layer (IF) of the pupal testes. Bouin HE.

Fig. 18. Illustrates intense staining of residual bodies with bromphenol blue, showing their protein nature. Bouin/BPB.

Fig. 19. Section showing the interfollicular layer (IF) of last larval instar testes, devoid of residual bodies.

The testes of late last larval instars show the presence of certain abnormal cysts, wherein the cells show clumping of metaphase-I, telophase chromosomes into irregular masses (Fig. 13). In contrast to these, the normal cysts which give rise to eupyrene spermatozoa show the formation of regular metaphase plates (Fig. 14). The cells of each maturing and elongating spermatocyst are associated with a nutritive cell present towards its apical end (Fig. 15). The sperm bundle consists of numerous filamentous spermatozoa aligned in a parallel manner and these are surrounded by a well defined sheath forming a compact unit (Fig. 16). A notable feature observed in the histological and histochemical preparations of the testes, is the occurrence of densely stained residual bodies within the cells of the inter-follicular layer of pupal testes (Fig. 17). The interfollicular layer is nothing but the inner double-walled peritoneum of the testis which forms the septa between adjacent follicles. The intense reaction of the residual bodies with bromphenol blue indicates their protein nature (Fig. 18). These bodies are absent in the late last instar (Fig. 19) and in the earlier stages of development.

DISCUSSION

The basic morphological features of the male reproductive system and testicular development in *Spodoptera litura* conform to the pattern reported for other lepidopterans (CHASE & GILLILAND, 1972; SALAMA, 1976; NUMATA & HIDAKA, 1980; LAI-FOOK, 1982; SCHEEPENS & WYSOKI 1985, 1986). Our observations show that the testes of *Spodoptera litura* grow gradually in size throughout the last larval instar and then it is followed by a period of rapid growth during the prepupal and pupal stages which coincides with the maturation of a large number of cysts. This is in close agreement with the sequence of testicular growth and differentiation reported for another noctuid moth, *Heliothis virescens* (CHASE & GILLILAND, 1972; LOEB *et al.*, 1984). The fusion of the paired larval testes takes place in the late prepupal stage. Ecdysteroids have been shown to control the fusion of the paired testes as well as the development of the rest of the genital tract in the pupae of *Heliothis virescens* and *Lymantria dispar* (LOEB *et al.*, 1986.)

The primary gonial cells in *Spodoptera* surround a central apical cell (ENGELMANN, 1970; LECLERCQ-SMEKENS, 1978). Contact with the apical cell is necessary for the transformation of initial germ cells into spermatogonia in *Euproctis chrysorrhoea*. The ultrastructual studies of the apical cells reveal them to be steroidogenic in nature. Furthermore, destruction of apical cells during early stages of development inhibits spermatogenesis in *Euproctis chrysorrhoea* (LECLERCQ-SMEKENES, 1978). These findings indicate the important role of apical cell in the differentiation of initial germ cells into spermatogonia and in the organization of spermatogenesis.

Our observations on *Spodoptera litura* reveal significant morphological changes in the spermatocysts of the testes during development of the insect and these are directly related to the process of differentiation of spermatocytes into mature spermatozoa. Like in many other lepidopterans (LAI-FOOK, 1982; KASUGA *et al.*, 1985; SCHEEPENS & WYSOKI, 1985; OSANAI *et al.*, 1986) the present species also possesses two types of spermatozoa - the eupyrene (nucleated) and apyrene(non-nucleated) types (ETMAN & HOOPER, 1979). Eupyrene meiotic divisions are regular and lead to spermatids having a spherical nucleus. These undergo transformation during spermiogenesis. In contrast to this, the apyrene meiotic divisions are irregular and lead to

the formation of spermatids having abnormal sets of chromsomes which are eventually discarded from the cells (FRIEDLANDER & WAHRMAN, 1971). The rate at which meiotic prophase proceeds during spermatogenesis determines the regular and irregular divisions of lepidopteran spermatocytes resulting in the formation of either eupyrene or apyrene spermatozoa (FRIEDLANDER & HAUSCHTECK- JUNGEN, 1986). The meiotic prophase of apyrene spermatocyte is shorter than that of eupyrene spermatocyte. It has been postulated that meiosis-specific proteins cannot be synthesized during the shortened apyrene prophase and this is correlated with abnormal chromosomal behaviour during metaphase-telophase stage (FRIEDLANDER & HAUSCHTECK-JUNGEN, 1986).

The divisions within a cyst are synchronous in *Spodoptera litura,* like in many other insect species. It has been suggested that such a synchronous differentiation within a cyst could be attributed to the existence of cytoplasmic bridges connecting the various cells with one another (FAWCETT, 1971; SZOLLOSI, 1975). A large number of degenerating spermatocysts are observed in the testes of *Spodoptera litura.* A similar event was reported for the testis of the beetle, *Hydrophilus olivaceus* (GUNDEVIA & RAMAMURTY, 1978). Nevertheless, a stable spermatocyte pool is maintained through continuous spermatogonial mitosis. The breakdown products of the degenerating spermatocysts may provide a pool of precursors for the development of other normal spermatocytes (LIMA DE FARIA & NORDQVIST, 1962).

In *Spodoptera litura* a large number of darkly stained dense granules have been observed in the interfollicular layer of the testes from the prepupal stage onwards. These granules may correspond to the residual bodies reported in mammalian testes (DAVIS & LANGFORD, 1970). Similar structures have been reported also in other insects, but usually inside the Sertoli cells (SZOLLOSI, 1975; RAY, 1978). The residual bodies may represent the cytoplasm extruded from spermatids during spermiogenesis. But their occurrence within the cells of the interfollicular septa is a notable peculiarity in the present species. In certain insects the residual bodies were shown to be ribonucleo-protein in nature, while in the present species they were found to be proteinaceous. It has been speculated that the RNA of the residual body may play a role in the regulation of spermatogenesis (MONESI, 1967).

REFERENCES

CHASE, J. A. & F. R. GILLILAND JR. (1972) Testicular development in the tobacco budworm. *Ann. ent. Soc. Am.*, **65**, 901–906.

DAVIS, J. R. & G. A. LANGFORD (1970) Testicular proteins, *in*: *The Testis.* vol. II (JOHNSON, A. D, W. R. GOMES & N. L. VANDEMARK, eds.), Academic Press, New York.

DONG, N., T. C. CARLYSLE, H. L. CROMROY & D. H. HABECK (1980) Morphological studies on the beet armyworm, *Spodoptera exigua* (Hübner) (Lepidoptera: Noctuidae). *Tech. Bull. Univ. Fla agric. Exp. Stn*, Gainesville, no: **816**.

ENGELMANN, F. (1970) *The Physiology of Insect Reproduction*, Oxford, Pergamon Press.

ETMAN, A. A. M. & G. H. S. HOOPER (1979) Developmental and reproductive biology of *Spodoptera litura* (F). (Lepidoptera: Noctuidae). *J. Aust. ent. Soc.*, **18**, 363–372.

FATZINGER, C. W. (1970) Morphology of the reproductive organs of *Dioryctria abietella* (Lepidoptera: Pyralidae). *Ann. ent. Soc. Am.*, **63**, 1256–1262.

FERRO, D. N. & R. D. AKRE (1975) Reproductive morphology and mechanics of mating of the codling moth, *Laspeyresia pomonella. Ann. ent. Soc. Am.*, **68**, 417–424.

FRIEDLANDER, M. & E. HAUSCHTECK-JUNGEN (1986) Regular and irregular divisions of Lepidopteran spermatocytes as related to the speed of meiotic prophase. *Chromosoma*, **93**, 227–230.

FRIEDLANDER, M. & J. WAHRMAN (1971) The number of centrioles in insect sperm. A study in two kinds of differentiating silkworm spermatids. *J. Morphol.*, **134**, 383–398.

GUNDEVIA, H. S. & P. S. RAMAMURTY (1974) Verson's cells and aberrant spermatozoa of *Hydrophilus olivaceus* (Fabr.) (Coleoptera: Hydrophilidae). *Int. J. Insect Morphol. Embryol.*, **3**, 121–125.

KASUGA, H., M. OSANAI & T. AIGAKI (1985) Post-testicular maturation of spermatozoa of the silkworm, *Bombyx mori*. *Zool. Sci.*, **2**, 953.

LAI-FOOK, J. (1982) Testicular development and spermatogenesis in *Calpodes ethlius* (Lepidoptera: Hesperiidae). *Can. J. Zool.*, **60**, 1161–1171.

LECLERCQ-SMEKENS, M. (1978) Reproduction of *Euproctis chrysorhoea* L. (Lepidoptera: Lymantriidae). II. Cytological aspects and the role of the apical cell (Verson cell) of the testicles. *Acad. R. Belg. Bull. Cl. Sci.*, **64**, 3188–3202.

LIMA-DE FARIA, A. & T. NORDQVIST (1962) Disintegration of ^{3}H-labelled spermatocytes in *Melanoplus differentialis*. *Chromosoma*, **13**, 60–66.

LOEB, M. J., E. P. BRANDT & M. J. BIRNBAUM (1984) Ecdysteroid prodution by testes of the tobacco budworm, *Heliothis virescens*, from last larval instar to adult. *J. Insect Physiol.*, **30**, 375–381.

LOEB, M. J., E. P. BRANDT, J. M. GIEBULTOWICZ & C. M. WOODS (1986) Endocrine regulation of the testes and of spermatogenesis in insects. *IV International Symposium on Invertebrate Reproduction*. Lille, France.

MISKIMEN, G. W., N. L. RODRIGUEZ & M. L. NAZARIO (1983) Reproductive morphology and sperm transport facilitation and regulation in the female sugar-cane borer, *Diatraea saccharalis* (F.) (Lepidoptera: Crambidae). *Ann. ent. Soc. Am.*, **76**, 248–252

MONESI, V. (1967) Ribonucleic acid and protein synthesis during differentiation of male germ cells in the mouse. *Arch. Anat. microscop. Morphol. Exp.*, **56**, 61.

NAGARKATTI, S. & S. PRAKASH (1974) Rearing *Heliothis armigera* on an artificial diet. *CIBC Tech. Bull.*, **17**, 169–173.

NUMATA, H. & T. HIDAKA (1980) Development of male sex cells in the swallowtail, *Papilio xuthus* L. (Lepidoptera; Papilionidae) in relation to pupal diapause. *Appl. Ent. Zool.*, **15**, 151–158.

OSANAI, M., T. AIGAKI, H. KASUGA & Y. YONEZAWA (1986) Role of arginase transferred from the vesicula seminalis during mating and changes in amino acid pools of the spermatophore after ejaculation in the silkworm, *Bombyx mori*. *Insect Biochem.*, **16**, 879–885.

OUTRAM, J. (1971) Morphology and histology of the reproductive system of the male spruce budworm, *Choristoneura fumiferana*. *Can. Ent.*, **102**, 404–414.

PHILLIPS, D. M. (1970) Insect sperm: their structure and morphogenesis. *J. Cell Biol.*, **44**, 243–277.

RAY, A. (1978) Neuroendocrinological and cell physiological studies of reproduction in some Indian Coleoptera. Ph. D. thesis, Banaras Hindu University, India.

ROOSEN-RUNGE, E. C. (1977) The process of spermatogenesis in animals. pp. 214, Cambridge, Univ. Press.

SALAMA, H. S. (1976) Spermatogenesis and testicular development in the gypsy moth, *Porthetria dispar*. L. Z. *Angew. Ent.*, **81**, 102–110.

SCHEEPENS, M. H. M. & M. WYSOKI (1985) Testicular development, spermatogenesis and chromosomes of *Boarmia selenaria* Schiff. (Lepidoptera: Geometridae). *Int. J. Invert. Repr. Devel.*, **8**, 337–348.

SCHEEPENS, M. H. M. & M. Wysoki (1986) Reproductive organs of the giant looper, *Boarmia selenaria* Schiff. (Lepidoptera: Geometridae). *Int. J. Insect Morphol. Embryol.*, **15**, 73–82.

SZOLLOSI, A. (1975) Electron microscope study of spermiogenesis in *Locusta migratoria* (Insecta: Orthoptera). *J. Ultrastruct. Res.*, **50**, 322–346.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 11 to 14

C-BANDED KARYOTYPE OF A COMMON POLYPHAGOUS APHID, *APHIS GOSSYPII* (HOMOPTERA : APHIDIDAE) : INDICATION OF STRUCTURAL REARRANGEMENTS

A. R. KHUDA-BUKHSH & I. KAR
Department of Zoology, University of Kalyani, Kalyani, India-741 235

(*Received* 4 *September* 1988)

C-banding of somatic metaphase complements of *Aphis gossypii* (2n = 8 chromosomes) revealed C-heterochromatin in either or both terminal ends of 1st and 2nd pairs while only one of the homologues of the 4th pair had an intercalary C-band. Further, one of the homologues of the 2nd pair had a terminal C-heterochromatin block at one end which lacked in the other member making the pair structurally unequal. On the basis of C-heterochromatin localization, structural rearrangements between different chromosomes have also been contemplated.

(*Key words:* C-banding, aphid, *Aphis gossypii*, karyotype, heterochromatin, translocation heterozygote)

INTRODUCTION

Although somatic karyotypes of over 700 species of aphids have so far been studied all over the world (ROBINSON & CHEN, 1969; KUZNETSOVA & SHAPOSHNIKOV, 1973; GUT, 1976; BLACKMAN, 1980a; 1986) including those of some 100 odd species from India (see KURL, 1986; KHUDA-BUKHSH & PAL, 1985, 1986a, b; KHUDA-BUKHSH & KAR, 1987 a, b; KHUDA-BUKHSH & BASU, 1987 etc.), C-banded karyotypes have been reported for 7 or 8 species till now (BLACKMAN, 1976, 1980b, 1984, 1985). The Induction of C-bands on aphid chromosomes by the conventional staining techniques of mammalian models is not very satisfactory. Thus suitable modifications, which again differ to some extent from species to species for giving reproducible results, are often necessary to inflict C-banding on aphid chromosomes. However, relatively high degree of intra-specific karyotypic variations, particularly in polyphagous, parthenogenetically reproducing forms of aphids, often lead to inconsistency in banding patterns of aphid chromosomes, a fact which has also been noted by BLACKMAN (1984). Our persistent attempt to induce C-bands on *Aphis gossypii* chromosomes yielded fairly consistent result, which has been presented in this communication.

MATERIAL AND METHODS

Preparations of somatic chromosomes were made from early embroyos of apterous viviparous females of *Aphis gossypii* Glover by deploying a modified squash-airdrying method (KHUDA-BUKHSH & PAL, 1984, 1985). For inducing C-bands, the method of BLACKMAN (1984) was essentially followed with minor modifications, such as, (i) the pH was brought to 12.4 instead of 12.0, (ii) the incubation in 2 X SSC was made at 60°C for 4 hours instead of 3 hours, and (iii) the treatment was made for 60 seconds in highly alkaline pH instead of 40 seconds.

RESULTS AND DISCUSSION

The typical diploid early metaphase complements (Fig. 1) contained 8 chromosomes alignable into 1 long, 2 medium and 1 short pairs (Fig. 2) depending on their

Fig. 1 Fig 2

C-banded early metaphase complement (Fig. 1) and karyotype (Fig. 2) of *A. gossypii*. Note the missing heterochromatic and in one homologue of the 2nd pair (arrowed) and the additional part in one homologue of 1st pair (arrowed). Bar indicates 10 μm.

lengths. Each pair was presumed to be homologues. C-heterochromatin was distributed along the greater part of the 3rd pair, forming both terminal and interstitial blocks. However, only one of the 4th homologues had deeply stained C-band positive zone in the middle while the other lacked it. One member of the 2nd pair had C-band at both the terminal ends while the other lacked the same at one end, thus making the pair unequal in size. Correspondingly, one homologue of the 1st pair had an extra heterochromatin block attached to one of its terminal ends, presumed to be the detached part of one member of the 2nd pair attached to the end of a 1st pair chromosome making the 1st pair also unequal like 2nd pair. The morphometric data (Table 1) corroborates well with the assumption that one part of one homologue of 2nd pair dissociated to join one end of one homologue of the 1st pair. Thus the C-banding pattern in *A. gossypii* demonstrated a karyotype bearing structural rearrangements by way of transposition involving one member each of the 1st and 2nd pairs. On the other hand the variable position of C-bands in the two homologues of 4th pair may indicate an inversion-like phenomenon rather unconventional to holocentric chromosomes (MANNA, 1985).

The aphid chromosomes are believed to be holokinetic in nature (WHITE, 1973; KUZNETSOVA, 1980; KHUDA - BUKHSH & DUTTA, 1981) for which structural rearrangements might not lead complication as evidenced in chromosomes with localised centromeres (MANNA, 1985). Thus frequent dissociation and / or fusion are encountered in natural populations of aphids, presumably having better adaptability to a specific micro-environment (i.e, host plant sap) or in response to combating adverse conditions (eg. insecticides or change in ecological conditions etc.). Thus intra-specific differences in the form or number of the chromosomes between samples may occur relatively frequently

TABLE 1. Mean length in μm and relative percentage length (RL) of individual chromosome in diploid complement of *A. gossypii*.

	Chrom. No.								Total Chrom. Length
	1	2	3	4	5	6	7	8	
Mean length (μm)	6.80	6.45	4.50	4.00	3.80	3.55	2.25	2.00	36.85
RL	18.45	17.50	12.21	10.85	10.31	9.63	6.10	5.42	

(BLACKMAN, 1980a, b), particularly in polyphagous aphids. A so-called translocation heterozygote (between autosome 1 and 3) of *Myzus persicae,* an extremely polyphagous aphid, has been demonstrated to have much greater resistance to organophosphorus insecticide malathion (BLACKMAN *et al.,* 1978). Karyotype variations in different populations have also been noted in another polyphagous species, *Lipaphis erysimi* (KHUDA-BUKHSH & PAL, 1981). There were also variable karyotypes of *Aphis gossypii* when examined from 14 host plant species (KHUDA-BUKHSH & KAR, 1988), the differences being statistically significant amog some host plant samples.

Where C-heterochromatin has been found in aphid karyotypes, it is normally located terminally, and the amount of terminal blocks varies in different species (BACKMAN, 1976, 1980b). Unusually high amount of C-heterochromatin was found in *Trama troglodytes* and several different karyotypes of the same species living sympatrically on the same root were encountered, some of which had several chromosomes wholly or mostly heterochromatic while others had small terminal or interstitial heterochromatic segments (BLACKMAN, 1980b). In *Euceraphis betulae,* C-banding demonstrated differences between X-chromosomes and B-chromosomes in mitotic cells (BLACKMAN, 1976). Therefore, it seemed that C-banding can be useful in demonstrating intra- or inter-specific differences and can focus on the structural rearrangements as well as karyotypic evolution in a given group, but further standaridization needs to be developed.

ACKNOWLEDGEMENTS

Grateful acknowledgement is made to CSIR, New Delhi, for the financial support of the work; to Prof. G. K. MANNA for encouragement and to the Head, Department of Zoology, University of Kalyani, for laboratory facilities; to Dr. M. K. GHOSH, BCKVV, Kalyani for the identification of the aphid specimens.

REFERENCES

BLACKMAN, R. L. (1976) Cytogenetics of two species of *Euceraphis* (Homoptera: Aphididae). *Chromosoma*, **56**, 393–408.

BLACKMAN, R. L. (1980a) Chromosomal numbers in the Aphididae and their taxonomic significance. *Syst. Ent.*, **5**, 7–25.

BLACKMAN, R. L. (1980b) *Insect Cytogenetics. Sym. Roy. ent. Soc.*, London, No. 10 (ed. R. L. BLACKMAN, G. M. HEWITT & D. ASHBURNER) Blackwell Scientific Publ., 133–148.

BLACKMAN, R. L. (1984) Evolution and biosystematics, Nadbitka. *Proc. Internatl Aphidol. Symp.* Jablonna, 1981, p. 171–237.

BLACKMAN, R. L. (1985) Spermatogenesis in the aphid *Amphorophora tuberculata* (Homoptera: Aphididae). *Chromosoma*, **92**, 357–362.

BLACKMAN, R. L. (1986) The chromosomes of Japanese Aphididae (Homoptera) with a note on the cytological work of Orihay Shinji. *Cytologia*, **51**, 59–83.

BLACKMAN, R. L., H. TAKADA & K. KAWAKAMI (1978) Chromosomal rearrangement involved in insecticide resistance of *Myzus persicae. Nature*, **271**, 450–452.

GUT, J. (1976) Chromosome numbers of parthenogenetic females of fiftyfive species of Aphididae (Homoptera) new to cytology. *Genetica*, **46** (3), 279–285.

KHUDA-BUKHSH, A. R. & G. BASU (1987) Karyotypic studies on five species of aphids (Homoptera : Aphididae) from the North-Eastern Himalayas. *Entomon*, **12** (3), 273–277.

KHUDA-BUKHASH, A. R. & S. DUTTA (1981) A preliminary note on the mitotic chromosome aberrations in embryos of whole-body X-irradiated parthenogenetic viviparous *Aphis gossypii* (Homoptera: Aphididae). *Chrom. Inf. Ser.*, **30**, 4–5.

KHUDA-BUKHSH, A. R. & I. KAR (1987a) Karyological studies in five species of Hormaphidine aphids (Homoptera : Aphididae). *Entomon*, **12** (3), 267–271.

KHUDA-BUKHSH, A. R. & I. KAR (1987b) Karyotypic studies in five species of *Macrosiphum* (Homoptera: Aphididae), *in: Perspectives in Cytology and Genetics*, Vol. VI (Eds. G. K. MANNA & U. SINHA) (In press).

KHUDA-BUKHSH, A. R. & N. B. PAL (1981) A Further cytological investigation on *Lipaphis erysimi* (Homoptera: Aphididae): Chromosomal variations, 403-49, *in : Perspectives in Cytology and Genetics* (Eds. G. K. MANNA & U. SINHA), Hindasia Publ., Vol. 4 (1984).

KHUDHA-BUKHSH, A. R. & N. B. PAL (1984) Karyomorphology of five species of aphids. *Environ. and Ecol.*, **2** (4) 329-332.

KHUDA-BUKHSH, A. R. & N. B. PAL (1985) Cytological studies on aphids (Homoptera : Aphididae) from India. I. Karyomorphology of eight species of *Aphis*. *Entomon*, **10** (2), 171-177.

KHUDA-BUKHSH, A. R. & N. B. PAL (1986a) Cytogenetical studies on aphids (Homoptera: Aphididae) from India. II. Karyomorphology of five species of *Myzus*. *Entomon*, **11** (2), 135-140.

KHUDA-BUKHSH, A. R. & N. B. PAL (1986b) Cytogenetical studies on aphids (Homoptera: Aphididae) from India. III. Karyomorphology of fifteen species belonging to the tribe Macrosiphini. *Entomon*, **11** (2), 141-147.

KURL. S. P. (1986) Chromosome numbers in aphids (Homoptera: Aphididae) of the world fauna. *Proc. 2nd Nat. Sym. Recent Trends in Aphidological Studies*, Modinagar, 1985, (Ed. S. P. KURL) pp. 119-165.

KUZNETSOVA, V. G. (1980) The way of karyotype evolution in insects with holokinetic chromo somes. *Proc. Insect Integrated taxonomy*, 16 *Internat. Congr. Ento.*, p. 85-89a-b.

KUZNETSOVA, V. G. & G. H. SHAPOSHNIKOV (1973) Chromosome numbers of aphids (Homoptera: Aphididae) of the world fauna (In Russian). *Ent. Obozr.*, **52**, 116-135.

MANNA, G. K. (1985) Centromeric enigma in Heteroptera, *in*: 77-88, *Recent Advances in Zoology* (Eds. C. B. L. SRIVASTAVA and SURESH C. GOEL), Rastogi & Company Publ. Meerut.

ROBINSON, A. G. & Y. H. CHEN (1969) Cytotaxonomy of Aphididae. *Can. J. Zool.*, **47** (4): 511-516.

WHITE, M. J. D. (1973) *Animal Cytology and Evolution*, University Press, Cambridge (3rd Edition) p. 961.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 15 to 18

A NEW SPECIES OF GENUS *MESOSTENUS* GRAVENHORST (HYMENOPTERA : ICHNEUMONIDAE) FROM INDIA

L. J. KANHEKAR[1] & P. K. NIKAM[2]
Regional Filaria Training and Research Centre, National Institute of Communicable Diseases, Rajahmundry, A.P., India 533 105

(*Received* 20 *July* 1988)

***Mesostenus townesi* sp. nov. is adequately described and key to Indo-Australian species of *Mesotenus* is provided**

(*Key words:* new species of *Mesosteus, Hymenoptera, Ichneumonidae*)

Mesostenus Gravenhorst (Ichneumonidae: Gelinae) is a moderate sized genus of worldwide distribution; species of this genus mostly occurs in rather dry habitats and some of them in deserts. Townes *et al.* (1961) synonymised *Stenaraeus* Thomson, *Umlima* Cameron and *Decocentrus* Cushman with *Mesostenus,* and included four species from Indo-Australian region *viz.*,*Umlima penetralis* Cameron (1902) *Stenaraeus punctatus* Szepligeti (1908), *S. ruficoxis* Szepligeti (1916), and *Mesostenus tricarinatus* Cameron (1906). Townes (1970) revised the genera of Gelinae and gave generic diagnosis, key characters, distribution etc., of this genus. In the present work, one new species. *M. townesi* is described and a key to the Indo-Australian species of *Mesostenus* is provided.

The type material of this species are in the collection of the author for the time being and will be deposited in the National Collection of Zoological Survey of India, Calcutta in due course.

Mesostenus townesi, sp. nov. (Figs. 1–3)

Female: Body (Fig. 1) 8.75 — 10.10mm. Head (Fig. 2) 0.90 as long as broad; vertex sparsely, finely punctate; ocello-ocular distance equal to the ocellar diameter, ocellar triangle densely, deeply punctate; frons medially longitudinally carinate, flat, closely punctate, laterally weakly elevated, finely punctate behind the antennal sockets; antennae 2+30 segmented; scape 1.25 times as long as broad; pedicel 2.25 times as long as broad; 1st flagellar segment 1.70 times the length of scape and pedicel combined 1.10 times the length of 2nd segment; terminal segment 2.50 times as long as broad; face 0.60 as long as broad, medially moderately longitudinally convex, densely punctate, laterally punctate; clypeus 0.55 as long as broad, distinctly separated, moderately convex, basally punctate, apically sparsely punctate, impressed; mandible moderately elongate, basally coarsely rugulose, teeth equal; cheek 0.65 the basal width of mandible, rugulose; temple moderately punctate; genal carina joining oral carina far above the base of mandible; occipital carina complete, occiput smooth.

Thorax 2.60 times as long as broad; collar weakly punctate; pronotum dorsally moderately swollen, coarsely, deeply punctate, with

[1] Part of Ph. D. thesis submited by the first author to Marathwada University under the guidance of the second author.

[2] Department of Zoology, Marathwada University, Aurangabad – 431 004.

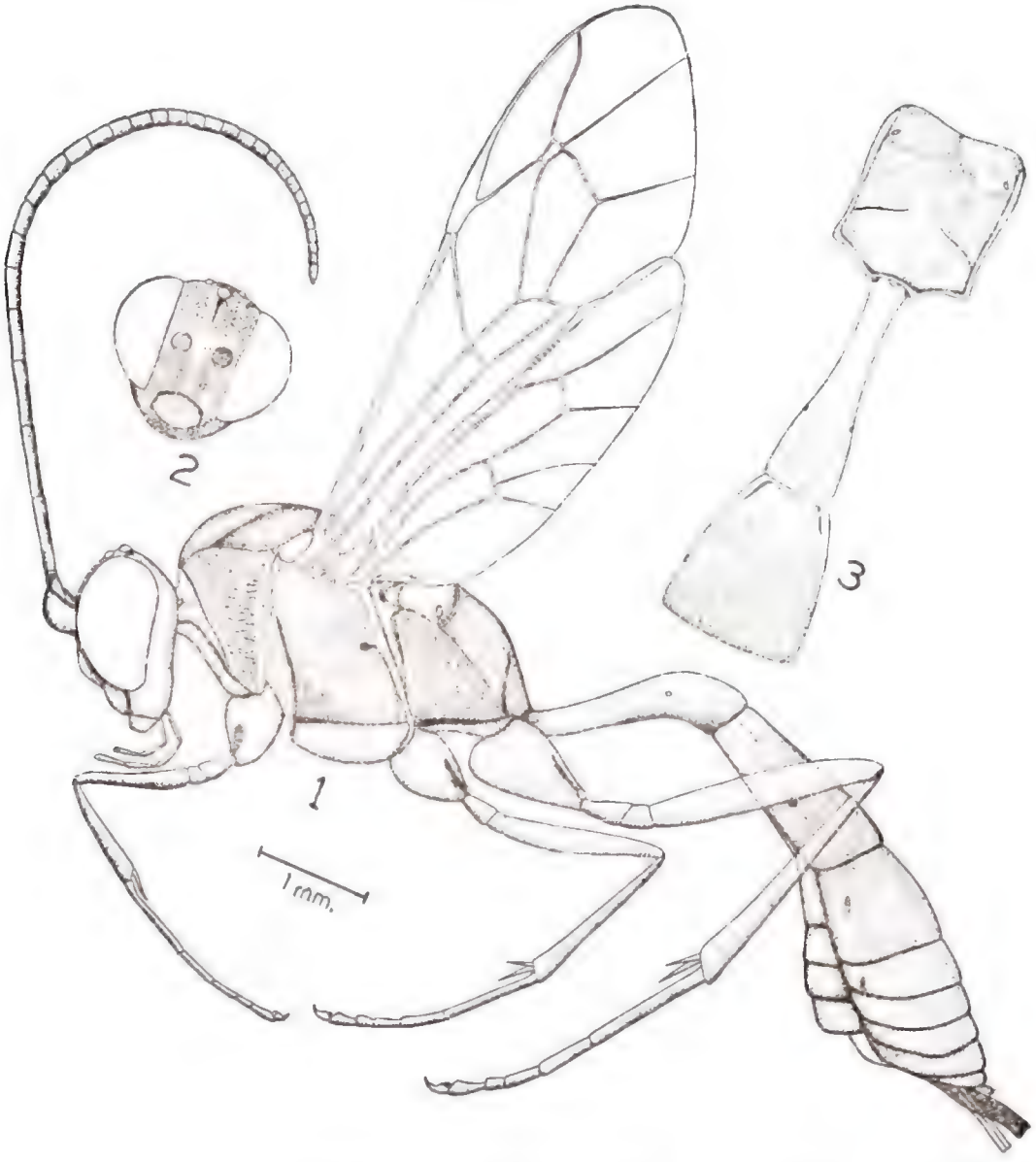


Fig. 1. *Mesostenus townesi* female; Fig. 2. Head; Fig. 3. Ist targite.

weak transverse striations, epomia moderately strong, reaching dorsad to lower edge of swollen upper margin of pronotum; mesoscutum deeply, coarsely punctate, notauli extending behind the middle; scutellum moderately convex, deeply punctate, lateral carinae restricted to base, elevated; postscutellum smooth and shiny; propodeum moderately punctate, median longitudinal carina present between base and basal transverse carina, basal and apical transverse carinae medially forwarded, latter medially

indistinct, spiracles elongate, 2.50 times as long as broad; propleurum finely densely punctate; mesopleurum closely, coarsely punctate except anteroventral corners densely so, sternaulus anteriorly distinct, posteriorly weak, mesopleural impression in the form of pit, speculum deeply punctate, subtegular ridge convex, deeply, densely punctate, prepectal carina reaching above the mid height of mesopleurum, prepectus deeply, coarsely punctate, postpectal carina incomplete; metapleurum widely, closely, coarsely punctate; juxtacoxal carina present; mid tibia 1.55 times the length of fore tibia; hind coxae 1.60 times as long as broad, femur 6.60 times as long as broad, basitarsus 2.20 times as long as 2nd tarsus, claw simple, curved, 3 times as long as broad.

Fore wing 6 — 6.60 mm long, 1.80 — 2.30 mm broad; basal abscissa of radius 0.70 the length of its apical abscissa; areolet sessile, pentagonal, 1.50 times as wide as high; 2nd intercubitus fenestrated; 2nd recurrent 0.55 the length of basal abscissa of subdiscoideus, reclivous, medially fenestrate; basal abscissa of subdiscoideus 1.10 times the length of its apical abscissa; discocubitus 2.20 times the length of basal abscissa of discoideus; nervulus 0.50 the length of postnervulus, slightly inclivious, opposite to basal vein; 2nd discoidal cell 2.45 times as long as broad; discocubital cell 2.85 times as long as broad; hind wing 4.10 — 4.70 mm long, 1 — 1.15mm broad, with 1+7 hamuli; basal abscissa of radiella 0.30 the length of its apical abscissa; mediella arculate; basal abscissa of cubitella 1.30 times the length of its apical abscissa; superior and inferior nervellar abscissae in the ratio of 7:3.

Abdomen 1.35 times the length of head and thorax combined; 1st tergite (Fig. 3) 3.30 times as long as broad. 1.30 times the length of 2nd tergite, with ventrolateral longitudinal carina, basally smooth and shiny, apically sparsely, weakly punctate, weakly curved, spiracles at 0.65; 2nd tergite basally smooth, rest closely punctate, thyridium little wider than long; 3rd tergite closely punctate; rest of the tergites finely to weakly, closely punctate; ovipositor sheath 1.15 times the length of hind tibia; ovipositor long, widened and angulated at nodus, tip of lower valve without oblique ridge, tip pointed.

Black. Palpi, all legs, targites 1–2, 3rd targite except apically, ovipositor and wing veins reddish-brown; antennae blackish-brown except apex of 6th to base of 10th segments laterally, frons laterally, collar anteromedially, subtegular ridge medially, tegulae, lateral carinae of scutellum, tergites 6–7 medio-apically whitish–yellow.

Male: Unknown.

Holotype: ♀, INDIA: MAHARSHTRA: Aurangabad, 3. iii. 1982, on wing, L. J. Kanhekar Coll., Antenna, wings and legs mounted on slides and labelled as above.

Paratype: 7 ♀♀, INDIA, MAHARASHTRA: Aurangabad, 1 ♀, 6. iii. 1982, 1 ♀, 9. xii. 1982, 1♀ 6. i. 1983, 1 ♀, 3. xii. 1983 (Donated to Dr. Townes, U. S. A.), 3 ♀♀ 8. iii. 1985. on wing L. J. Kanhekar Coll.

Remarks: This species is close to *M. ruficoxis*; but differs from it by the presence of clypeo-facial suture, face black, antennae banded and shorter than body length, fore coxae brown, hind coxae and postpetiole punctate.

The name *townesi*, is in honour of Dr. Henry Townes, for his contribution to the field of parasitic Hymenoptera.

KEY TO THE INDO-AUSTRALIAN SPECIES OF *MESOSTENUS* GRAVENHORST

1. Nervlus opposite to basal vein; stigma brown: hind coxae red or brown..... 2
   Nervulus based to basal vein (except in *tricarinatus* Cam.); stigma and hind coxae black.. 3

2. Face white; clypeus not separated from face; antennae as long as body length, without band; scutellum smooth and shiny; fore coxae yellow; hind coxae smooth; postpetiole smooth. Lambeh Is., Singapore..... .....*ruficoxis* Szepligeti, 1916.
   Face black; clypeus separated from face; antennae shorter than body length, banded; scutellum punctate; fore coxae brown; hind coxae punctate; postpetiole punctate. India. .....*townesi*, sp. nov.
3. Face closely, finely rugosely punctate; antennae banded; tegulae black. Vertex smooth and shiny; propodeum strongly punctate; areolet as long as broad. India..... .....*penetralis* Cam., 1902
   Face punctate; antennae without bands; tegulae yellow or white..... 4
4. Vertex punctate; mesoscutum strongly, closely punctate ; scutellum medially black; fore coxae yellow; wing hyaline; 2nd tergite smooth. Areolet narrow, receiving 2nd recurrent at apex, 2 times as long as broad. Pakistan..... .....*tricarinatus* Cameron, 1906
   Vertex smooth; mesoscutum sparsely punctate; scutellum white; fore coxae brown; wings brownish: 2nd tergite finely punctate. Ovipositor shorter than abdomen. Java..... .....*punctatus* Szepligeti, 1908

ACKNOWLEDGEMENTS

The autors are grateful to Prof. R. NAGABHUSHANAM, Head, Department of Zoology, Marathwada University, Aurangabad for providing laboratory facilities and to CSIR, New Delhi for awarding a Junior and Senior Research Fellowship to senior author.

REFERENCES

CAMERON, P. (1902) XXXIV — Description of new genera and species of Hymenoptera from the Oriental Zoological Region (Ichneumonidae, Fossores, and Anthophile). *Ann. Mag. nat Hist.*, **7** (9), 204–215.

CAMERON, P. (1906) On the Tenthredinidae and parasitic Hymenoptera collected in Baluchistan by Major C. G. Nurse. *J. Bombay nat. Hist. Soc.*, **17**, 274–288.

SZEPLIGETI, G. V. (1908) E. Jacobson'sche Hymenopteran aus Searamg (Java). Evaniden, Braconiden und Ichneumoniden. *Notes Leyden Mus.*, **29**, 209–261.

SZEPLIGETI, G. V. (1916) Ichneumoniden aus der Sammlung der Ungarischen National Museum – II. *Ann. Mus. Natl. Hungarici*, **14**, 224–280.

TOWNES, H. (1970) The genera of Ichneumonidae. Part. II. *Mem. Amer. ent. Inst.*, **12**, 1–537.

TOWNES, H., M. TOWNES & V. K. GUPTA (1961) A catalogue and reclassification of the Indo-Australian Ichneumonidae. *Mem. Amer. Ent. Inst.*, **1**, 1–522.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 19 to 20

FEEDING POTENTIAL AND DEVELOPMENT OF GREEN LACEWING *MALLADA BONINENSIS* (OKAMOTO) ON THE GRAPE MEALYBUG, *MACONELLICOCCUS HIRSUTUS* (GREEN)

M. MANI & A. KRISHNAMOORTHY
Biological Control Laboratory I
Division of Entomology and Nematology
Indian Institute of Horticultural Research, Bangalore, India 560 089

(*Received* 20 *July* 1988)

The green lacewing *Mallada boninensis* (Okamoto) is a common predator of the pink mealybug, *Maconellicoccus hirsutus* (Green) infesting grapevine. Results of the study indicate that the development of *M. boninensis* was completed in 25.80 days on *M. hirsutus*. A single chrysopid larva consumed 237.90 mealybug nymphs in its larval development.

(*Key words:* *Mallada boninensis*, *Maconellicoccus hirsutus*, green lacewing, mealybug, feeding potential, development)

Earlier, the chrysopid, *Mallada* (=*Chrysopa*=*Anisochrysa*) *boninensis* (Okamoto) has been reported predating on the grape mealybug, *Maconellicoccus hirsutus* (Green) (KRISHNAMOORTHY & MANI, 1988) and cassava mealybug *Phenacoccus manihoti* Matileferrero (BOUSSIENGUET, 1986). The present study was conducted to determine the feeding potential and development of *M. boninensis* on *M. hirsutus*.

The culture of *M. hirsutus* was maintained on pumpkin fruits and *M. boninensis* on the rice moth *Corcyra cephalonica* (Staint). The predatory larvae just after hatching were transferred and confined individually in glass vials (7.5×2.5 cm). They were provided with known number of 10 day old mealybug nymphs. The vials were then closed with cloth walled cotton plugs. Observations were made at an interval of 24 h, on the number of mealybug nymphs preyed. Mealybugs left unpreyed were removed and known number of fresh nymphs were offered to the predator daily until cocoons were formed. This study was conducted with 20 chrysopid larvae considering each larva as one replicate. Another batch of predatory larvae was provided with rice moth eggs till the cocoons were formed.

Developmental period of different larval instars and pupal period were recorded. The experiments were conducted in the laboratory at 26 ± 1°C and 60–67% relative humidity.

The number of mealybug nymphs consumed during first, second and third instars of predator averaged 34.80, 37.20 and 165.90 respectively. Third instar larvae were more voracious and very active. A total of 237.90 host nymphs were consumed by a single predator larva in its development (Table 1).

Development of *M. boninensis* was completed in 21.85 days on *C. cephalonica* and 25.5 days on *M. hirsutus*. Incubation period ranged from 4 to 5 days. A total of 9.25 days was required to complete the larval development on rice moth whereas it took 11.30 days on the mealybug. Cocoon period was 8.35 and 10.10 days when the chrysopid

Contribution No. 142/88 of I.I.H.R.

TABLE 1. Feeding potential of *M. boninensis* on *M. hirsutus*.

Larval instar	No. mealybugs consumed
I	34.80 ± 3.40
II	37.20 ± 4.34
III	165. ± 9 ± 14.56
Total consumption	237.9 ± 16.44

TABLE 2. Development of *Mallada boninensis* on the mealybug and rice moth.

Chrysopid stages	Developmental period in days	
	Rice moth	Mealybug
Egg	4.25 ± 0.21	4.10 ± 0.18
Larva		
I Instar	3.20 ± 0.69	3.90 ± 0.88
II Instar	2.25 ± 0.42	2.80 ± 0.74
III Instar	3.80 ± 0.51	4.60 ± 0.48
Cocoon	8.35 ± 0.68	10.10 ± 1.17
(Total egg to adult)	21.85 ± 1.24	25.50 ± 0.53

was reared on rice moth and mealybug respectively (Table 2). According to BRETTELL (1979), egg, larva and pupal stages of *M. boninensis* averaged 3.7, 12.0 and 10.0 days respectively at 25° C. LEE & SHIH (1981) also reported shorter life cycle of *M. boninensis* on *C. cephalonica* when compared with the development on *Paurocephala psylloptera* Crawford.

ACKNOWLEDGEMENTS

The authors are thankful to Director, IIHR, Bangalore for providing facilities to conduct the research.

REFERENCES

BOUSSIENGUET, J. (1986) The natural enemy complex of Cassava mealybug, *Phenacoccus manihoti* (Ham., Coccoidea, Pseudococcidae) in Gabon. I. Faunistic inventory and trophic relationship. *Annels de la Societe Entomologique de France*, **22**, 35–34.

BRETTELL, J. H. (1979) Green lacewings (Neuroptera: Chrysopidae) of cotton fields in Central Rhodesia. I. Biology of *Chrysopa boninensis* Okamoto. *Rhodesian J. agric. Res.*, **17**, 141–150.

KRISHNAMOORTHY, A. & M. MANI (1988) Records of green lacewings preying on mealybugs in India. *Curr. Sci.*, (In Press).

LEE, S. J. & C. H. SHIH (1981) Biology, predation and field cage release of *Chrysopa boninensis* Okamoto on *Paurocephala psllyoptera* Crawford and *Corcyra cephalonica* Staint. *Chinese J. Ent.*, **1**, 123–124.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 21 to 24

CONTRIBUTION OF TISSUE PROTEINS TO THE COCOON SHELL IN THE 5TH INSTAR SILKWORM *BOMBYX MORI*

GEETA JADHAV & V. L. KALLAPUR
Department of Studies in Zoology, Karnatak University, Dharwad, India 580 003

(*Received* 20 *July* 1988)

The synthesis of proteins from the injected radiolabelled amino acid during 5th instar larval development revealed that both fat body and integument synthesize proteins and accumulated them during early and mid larval development. However, the protein level was significantly depleted in both tissues at the time of spinning the cocoon. The fat body of the pharate pupa showed significant increase in protein level. It was proposed that the proteins of the degenerating integument were used for the silk protein synthesis by the larva during spinning period.

(*Key words:* proteins, cocoon shell, silkworm, *Bombyx mori*)

INTRODUCTION

The synthesis of cocoon proteins at the time of spinning is a remarkable phenomenon in the development of the silkworm, *Bombyx mori*. At this stage the larva does not feed. The earlier experiments of FUKUDA (1959) and FUKUDA & FLORKIN (1959a, b) have demonstrated that in the spinning stage silk protein synthesis took place at the expense of the degeneration of some tissues. NOGUCHI *et al.* (1974) have also opined that silk formation in the spinning period is largely controlled by the level of reserves supplied from the degenerating tissues. One of the tissues that exhibit greater rate of degeneration at the onset of spinning process is the integument (JADHAV, 1987). In the present study an attempt is made to illustrate the possible involvement of fat body and integumentary proteins to the silk protein production.

MATERIALS AND METHODS

The laboratory bred bivoltine ('NB_4 D_2') 5th instar silkworms were used as experimental insects. The rearing technique was similar to that described by KRISHNASWAMY *et al.* (1978). In the present study, the experiments were started with 2 day old larvae (48 h after 4th moult).

In vivo incorporation of (U-^{14}C) leucine, into various tissue proteins was determined by injecting five microliters of labelled leucine (350 m Ci/m mole, specific activity). After 120 min (time required for maximum incorporation, JADHAV, 1987), the hemolymph was collected in a cold culture tube by cutting off one of the thoracic appendages. After draining the hemolymph, the larva was dissected in a cold *Bombyx* saline (YAMAOKA *et al.*, 1971). The abdominal fat body was carefully removed and washed twice with ice-cold *Bombyx* saline. The fat body was blotted and weighed accurately and processed. After removing all the organ systems-, trachea and adhering fat body the remaining body wall was designated as the integument. The tissues were processed for the determination of radioactivity in the protein according to the method described by MANS & NOVELLI (1961). The radioactivity was measured on Beckman liquid Scintillation counter. The total protein content of a tissue was estimated according to the method

of LOWRY *et al.* (1951) using bovine serum albumin (fraction IV, Sigma Chemical Company, U. S. A.) as reference standard.

RESULTS AND DISCUSSION

The results of the present study were summarised in Table 1 and Fig. 1. The larvae of *B. mori* exhibit a phenomenal rate of growth during 5th instar stage. The increase in growth accompanied by increased feeding activity and utilization of organic fuel reserves accumulated in the fat body. Studies have shown that the larval fat body stores large quantity of proteins during early stage and they are secreted into the hemolymph at the late larval stage (SHIGEMATSU & TAKESHITA, 1959; SHIGEMATSU, 1960; UENO & NATORI, 1982; SAITO & ROBERTS, 1983). The fate of these proteins is not clearly understood. The fat body forms these granules by the absorption and storage of hemolymph proteins (LOCKE & COLLINS, 1968). It is evident from present study that the rate of protein synthesis from the injected labelled amino acid in the fat body of both male and female larvae increased upto the 5th day of development. During the subsequent development of 5–7 days the recovery of labelled proteins remained at the same level. However, in 8 day old larvae the protein synthesis was reduced by 40% (Table 1). These observations suggest that the fat body in the early 5th instar assumes synthetic activity and accumulates large quantity of proteins. In the late larvae the fat body acts more as a storage organ.

The protein synthesis in the integument (from the labelled amino acid) and total

TABLE 1. Incorporation of labelled amino acid, protein content and protease activity in 5th instar *B. mori*.

Age (day)	DPM/100 mg fresh tissue or μl hemolymph				
	Fat body (male)	Fat body (female)	Integument (female)	Hemolyph (female)	Protease activity
2	12000 ± 80p	14400 ± 192p (9.2 ± 0.9)a	11200 ± 160p (50.0 ± 1.6)a	1920 ± 128 (6.0 ± 0.7)a	1.9 ± 0.06a
3	20000 ± 192q	22400 ± 240q (14.0 ± 1.0)b	20800 ± 264q (65.0 ± 1.0)b	2080 ± 128 (6.5 ± 0.5)a	1.8 ± 0.09a
5	32000 ± 480r	33600 ± 320r (23.0 ± 1.2)c	24000 ± 240q (76.0 ± 3.0)c	2080 ± 128 (6.0 ± 0.8)a	2.5 ± 0.02b 2.6 ± 0.01
7	33600 ± 352r	35200 ± 640r (23.0 ± 1.2)c	25600 ± 160q (81.0 ± 5.0)c	1920 ± 96 (6.0 ± 0.6)a	2.6 ± 0.01b
8	19200 ± 288s	16000 ± 160s (16.0 ± 1.6)d	8000 ± 176r (54.0 ± 2.3)d	2080 ± 144 (9.5 ± 0.12)b	2.92 ± 0.01c
Pharate pupa	25600 ± 272t	24000 ± 256t (45.0 ± 0.9)e	— (30.0 ± 4.0)e	— (9.3 ± 1.0)b	—

The results indicate mean ± SE of five determinations.
The total protein value (mg/100 mg fresh tissue) is given in parentheses.
Protease activity is expressed as μg tyrosine equivalent released/mg protein/min (Jadhav, 1987).
The different superscripts in each vertical column indicate the results that are significantly different ($P<0.001$).

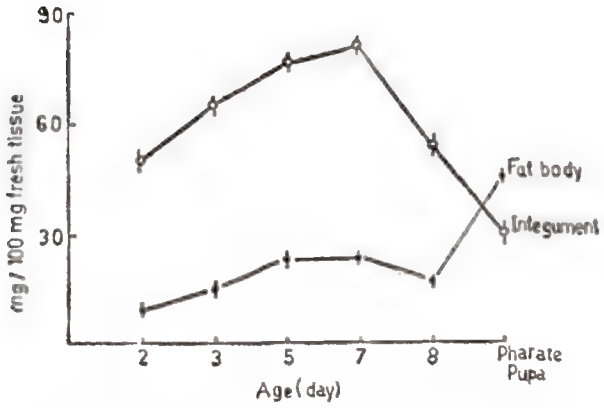


Fig. 1. Protein content of fat body and integument during 5th instar larval development of *Bombyx mori*.

protein content increased by 128% and 37% respectively on 7th day of larval development when compared to 2 day old larvae. This remarkable increase in protein level is to accommodate 5 fold increase in growth of the cuticle in both surface area and thickness (JADHAV, 1987). In 8 day old larvae, both labelled proteins and total proteins significantly reduced in fat body and integument. The synthesis of silk proteins for spinning the cocoon puts a great demand for proteins. The spinning of cocoon begins on 8th day and the larva stops feeding 1–2 days before spinning stage begins. The protein requirement has to be met out from the other organs. The hemolymph proteins in 8 day old larvae exhibited significant increase (Table 1). It is possible that proteins from both integument and fat body are diverted to the silk gland for the synthesis of silk proteins. The fat body of the pharate pupa shows significant increase in both labelled proteins and other proteins (TCA extractable ones). These observations suggest that the fat body proteins released into the hemolymph at the time of spinning stage are actively taken up by the fat body of pharate pupa. The proteins of the integument on the other hand are diverted to the silk gland for the synthesis of silk proteins. This assumption is supported by the finding that proteolytic activity in 8 day old larval integument is increased significantly (Table 1). The present study provides an evidence in support of the earlier suggestion of NOGUCHI *et al.* (1974) that silk formation in the spinning period is largely controlled by the level of reserves supplied from the degenerating tissues.

REFERENCES

FUKUDA, T. (1959) The correlation between the mulberry leaves taken by the silkworm, the silk protein in the silk gland and the silk filament. *Bull. sericult. Exp. Sta.*, **15**, 595–610.

FUKUDA, T. & M. FLORKIN (1959a) Contribution to silkworm biochemistry. vi. Time of biosynthesis of fibroin and its location in the reservoir of the silk gland at the end of the fifth age. *Arch. Int. Physiol. Biochem.*, **67**, 214–221.

JADHAV, J. K. (1987) Protein metabolism in the 5th instar larva and pupa of the silkworm, *Bombyx mori* (L.). M. Phil. Dissertation, Karnatak University, India.

KRISHNASWAMY, S., M. N. NARASIMHANNA, S. K. SURYANARAYAN & S. KUMARARAJ (1978) *Sericulture manual*. Vol. 2, FAO bulletin. Rome.

LOCKE, M. & J.V. COLLINS (1968) Protein uptake into multivesicular bodies and storage granules in the fat body of an insect. *J. Cell Biol.*, **36**, 453–483.

LOWRY, O. H., N. F. ROSENBROUGH, A. L. FARR & R. J. RANDALL (1957) Protein measurement with folin phenol reagent. *J. biol. Chem.*, **193**, 265–275.

MANS, R. J. & G. D. NOVELLI (1961) Measurement of the incorporation of radioactive amino acids into proteins by a filter paper disk method. *Arch. Biochem. Biophys.*, **94**, 48–53.

SAITO, J. D. & D. B. ROBERTS (1983) Synthesis of larval serum proteins one and two of *Drosophila melanogaster* by third instar fat body. *Insect Biochem.*, **13**, 1–5.

SHIGEMATSU, H. & H. TAKESHITA (1959) On the changes in the weight of the fat body and of its chief constituents in the silkworm, *Bombyx mori* L., during metamorphosis. *Jap. J. Appl. Ent. Zool.*, **3**, 123–127.

SHIGEMATSU, H. (1960) Protein metabolism in the fat body of silkworm, *Bombyx mori* L. *Bull. sericult. Exp. Sta.*, **16**, 141–170.

UENO, K. & S. NATORI (1982) Activation of fat body by 20-hydroxyecdysone for the selective incorporation of storage proteins in *Sarcophaga perigrina* larvae. *Insect Biochem.*, **12**, 185–191.

YAMAOKA, K., M. HOSHINO & T. HIRAO (1971) Role of sensory hairs on the anal papillae in oviposition behaviour of *Bombyx mori*. *J. Insect Physiol.*, **17**, 897–911.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 25 to 27

A NEW SPECIES, *RHADINOMERUS SULCIPENNIS* (CRYPTORHYNCHINAE : CURCULIONIDE : COLEOPTERA) FROM NORTH ANDAMAN ISLAND

LEHNA SINGH[1] & H. R. PAJNI
Department of Zoology, Panjab University, Chandigarh, India 160 014

A new weevil species, *Rhadinomerus sulcipennis* is described in detail.

(*Key words*: new species, weevil)

INTRODUCTION

The cryptorhynchid weevils belonging to genus *Rhadinomerus* are commonly called wood-borers which in association with other borers destroy discarded forest wood-logs and timber. Sixteen species of this genus have so far been reported from India (Marshall, 1921, 1931, 1933, 1936, 1938), of which 14 species are known from Dehradun (U. P.) and Darjeeling (W. B.). Indian Islands are represented in the collection of the Forest Research Institute, Dehradun by two species namely *Rhadinomerus apicetumens* and *R. crinipes* (Marshall, 1933) both from North Andaman. The present species collected from the same area was obtained on loan from the unidentified collections of the Entomological Museum of the Forest Research Institute, Dehradun (U. P.) and detailed description of the species including its external genitalia is given in this paper.

Description:

Head piceous, coarsely and reticulately punctate, densely clothed with arenaceous recumbent fan-shaped scales in front concaling punctures; frons with shallow and small sulcus partly covered by scales; eyes black, subapproximate below, with interocular space below; rostrum punctate. Rostrum piceous, slightly broader than frons at base. Subcylindrical, longer than pronotum, acarinate, punctate in basal third glabrous behind, furnished with recumbent light-brown scales only at base. Antennae reddish-brown, inserted behind middle of rostrum; funicle finely pubescent, with segment 1 as long as 2; club fusiform, compact.

Pronotum piceous, almost as along as broad, bisinuate at base, truncate at apex, coarsely and rugosely punctate with punctures large and slanting inwards, provided with sparse recumbent scales and setae but for apical area which is densely clothed with scales, with median carina obliterated. Scutellum black, rounded, rather sparsely setose.

Elytra ferruginous, much broader at base than pronotum, subcordate, with roundly rectangular humeri, with prominent subapical calli; interval broader than striae, strongly rugose at base, impregnated with a row of granules distinctly visible at base, densely clothed with recumbent arenaceous scales besides also provided with a row of erect setae sprouting from centre of granules, with intervals 2–4 costate at base but flattened behind, with interval I depressed in basal third to form a channel; vestiture dark brown variegated with black patches and a black horizontal band extended from intervals 2 to 6 on either elytron behind middle.

[1]Biologist, Urban Malaria Scheme, Thanesar, Kurukshetra-132 118, (Haryana), India.

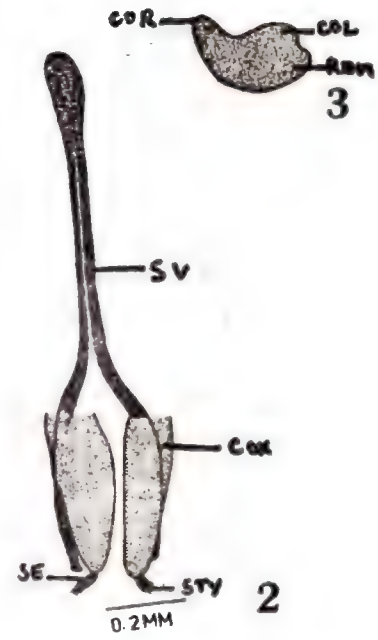


Fig. 1. Adult of *R. sulcipennis* sp. nov. Fig. 2. Female genitalia. Fig. 3. Spermatheca. Col: Collum; COR: Cornu; CO: Coxite; RAM; Ramus; SE: Setae; STY: Stylus; SV: Spiculum Ventrale

Legs with femora uniformly clothed with overlapping dark-brown scales, hind femora each with a black patch in middle flanked by pale patches; tibiae curved at base almost straight, furnished with black scales in basal third and with pale scales interspersed with pale setae in remaining region; tarsal segment 1 as long as 2 and 3 combined.

Sternal canal reaching hind end of mid-coxae. Metasternum covernous, closely punctate with each puncture bearing a pale recumbent seta. Abdominal sternite 1 punctate with punctures rather deep and wide just behind coxae but small and scattered elsewhere; sternite 2 longer than 2 and 3 combined, scatteredly punctate, sternites 3 and 4 each with a horizontal row of small and shallow punctures; sternite 5 closely punctate, furnished with sparse setae as well as scales.

Female genitalia with coxites tubular, rather long; styli cylindrical, two times as long as broad; furnished with dense setae at apex. Spiculum ventrale with median arm straight, slightly broadened at tip; lateral arms relatively small, as sclerotized as median. Spermatheca relatively small, with cornu only slightly curved; collum and ramus indistinct.

Measurements:

Body length	Body width
5.28 – 6.14 mm	2.45 – 2.85 mm
Rostrum length	Rostrum width
1.40 – 1.70 mm	0.28 – 0.42 mm

Specimens examined : 3

Holotype: Female; North Andaman; *Sterculia campanulata*; B. M. Bhatia coll. 16. xii. 1928.

Paratypes: 2 females; data same as that of holotype.

Type Depository: Entomological Museum, Forest Research Institute, Dehradun (U.P.)

Remarks: This species is quite different from *R. apicetumens* Marshall and *R. crinipes* Marshall, the two species recorded from North Andaman, in general disposition and other important characters such as rostrum acrinate, base of elytra rugulose and subapical calli rather prominent. However, it superficially resembles *R. diversipes* but differs from it in the punctation of pronotum, disposition of scales on elytra particularly in having a depressed sutural area at the base of elytra forming a short shallow channel.

ACKNOWLEDGEMENTS

The authors are thankful to Dr. P. K. SEN-SARMA, Director, Biological Sciences, F.R.I., Dehradun (U.P.) for lending the material for the present study. The present study was carried out under US PL-480 scheme on Curculionidae in which the senior author had worked as a Senior Research Fellow and submitted this work for his Ph.D. thesis. Besides, the facilities for research provided by the Chairman, Department of Zoology, Panjab University, Chandigarh, are also acknowledged.

REFERENCES

MARSHALL, G. A. K. (1921) On new species of Curculionidae attacking forest trees in India. *Bull. ent. Res.*, **12**, 165–180.

MARSHALL, G. A. K. (1931) New Indian Curculionidae (Col.). *Indian For. Rec., Ent.*, **16**, 263–278.

MARSHALL, G. A. K. (1933) On new Indian Curculionidae (Col.). *Mag. nat. Hist.*, **10** (12), 565–583.

MARSHALL, G.A.K. (1936) New Indian Curculionidae (Col.). *For. Rec.* (*N.S.*) *Ent.*, **I**, No. 11, 205–231.

MARSHALL, G.A.K. (1938) New Indian Curculionidae (Col.). *For. Rec.* (*N.S.*) *Ent.*, **3**, 168–172.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 29 to 32

HITHERTO UNKNOWN MORPHS OF *EUMYZUS PRUNI* AND *METOPOLOPHIUM SIMLAENSIS* (HOMOPTERA · APHIDIDAE) FROM WESTERN HIMALAYA, INDIA

P. K. MEDDA[1] & S. CHAKRABARTI
Biosystematics Research Unit, Department of Zoology, University of Kalyani, Kalyani, India 741 235

(*Received* 12 *June* 1988)

Descriptions of hitherto unknown apterous oviparous female and alate male of *Eumyzus pruni* Chakrabarti and Bhattacharya, and alate viviparous female of *Metopolophium simlaensis* (Chakrabarti and Raychaudhuri) collected from Western Himalaya, India are provided.

(*Key words*: unknown morphs, aphids, morphology, Western Himalaya, India)

Eumyzus pruni Chakrabarti and Bhattacharya was so far known by its apterous and alate viviparous female morphs (Chakrabarti and Bhattacharya, 1985; Medda and Chakrabarti, 1986) infesting *Prunus cornuta*. Apterous oviparous female and alate male morphs are discovered from the same host plant during the period of winter. The discovery of sexual morphs indicates its holocyclic nature. Moreover, appearance of nymphs of these sexuals indicates that they are produced on this host plant.

Another species, *Metopolophium simlaensis* (Chakrabarti and Raychaudhuri), originally described as *Acyrthosiphon* (*Metopolophium*) *simlaensis* (in Chakrabarti *et al.*, 1974) was so far known by its apterous viviparous female only. Here, its unknown alate viviparous female morph is described.

Abbreviations used: aptera – apterous viviparous female; alata/e = alate viviparous female/s; oviparae = apterous oviparous females; b.d. III = basal diameter of antennal segment III; p.t. = processus terminalis; u.r.s. = ultimate rostral segment; h.t.2 = second joint of hind tarsus; F.T.C. = first tarsal chaetotaxy.

Eumyzus pruni Chakrabarti and Bhattacharya

Apterous oviparous female : Body 1.28–1.55 mm long and 0.60–0.80 mm wide. Head scabrous with hardly developed lateral frontal tubercles and median frontal prominence; dorsum with 5 pairs of hairs with blunt to 'myzine-type' apices, longest one on vertex 13–16 μm long and 0.58–0.69 times the b.d.III. Antennae 0.36–0.43 times the body; segments I and II with 4–5 and 3 hairs respectively; longest hair on segment III 7–9 μm long and 0.31–0.42 times the b.d. III; p.t. 1.33–1.50 times the base of segment VI and 0.78–1.0 times the segment III. U.r.s. 0.90–1.0 times the h.t.2. Mid-thoracic furca with separate arms. Abdomen pale brown; dorsal hairs short and with 'myzine-type' apices; longest hair on anterior tergites 7–11 μm long and 0.33–0.50 times the b.d. III; tergites 7 and 8 with 5–7 hairs and 6 hairs respectively having acuminate apices, longest

[1]Present address: Department of Zoology, Ramakrishna Mission Vivekananda Centenary College, Rahara 743 186

one on them 18–23 μm and 29–34 μm long, and 0.77–1.08 times and 1.33–1.58 times the b.d.III respectively. Siphunculi about 0.09 times the body and 1.27–1.42 times the cauda. Cauda with 6 hairs. Venter finely spinulose. Subgenital plate with 3–4 hairs on anterior margin and 10–18 hairs on posterior margin. Legs uniformly brown, tibiae swollen and with 75–83 pseudosensoria. F.T.C. 3,3,2. Other characters as in aptera.

Measurements of one specimen in mm :

Body length 1.55, width 0.88; antenna 0.59; antennal segments III:IV:V:VI 0.14:0.08: 0.08: (08 + 0.12) u.r.s. 0.09; h.t. 2 0.10; siphunculus 0.14; cauda 0.10.

Alate male : Body about 1.68 mm long and 0.68 mm wide. Longest hair on vertex about 18 μm long and 0.63 times the b.d.III. Antennae about 0.74 times the body; segments III, IV and V with 41–52, 13–22 and 10–11 secondary rhinaria respectively; longest hair on segment III about 11 μm long and 0.38 times the b.d.III; p.t. about 1.64 times the base of segment VI and 0.39 times the segment III. U.r.s. as long as the h.t.2. Longest hair on anterior tergites and on tergites 7 and 8 about 18 μm, 20 μm and 32 μm long and 0.63 times, 0.69 times and 1.13 times the b.d.III respectively; tergite 7 with a spinal tubercle. Siphunculi about 0.08 times the body and 1.4 times the cauda. Cauda with 5 hairs. Venter finely spinulose. Male genitalia with well developed aedeagus. F.T.C. 3,3,2. Other characters as in alata.

Measurements of the specimen in mm :

Body length 1.68, width 0.68; antenna 1.25; antennal segments III:IV:V:VI 0.46:0.20: 0.18:(0.11 + 0.18); u.r.s. 0.10; h.t.2 0.10; siphunculus 0.14; cauda 0.10.

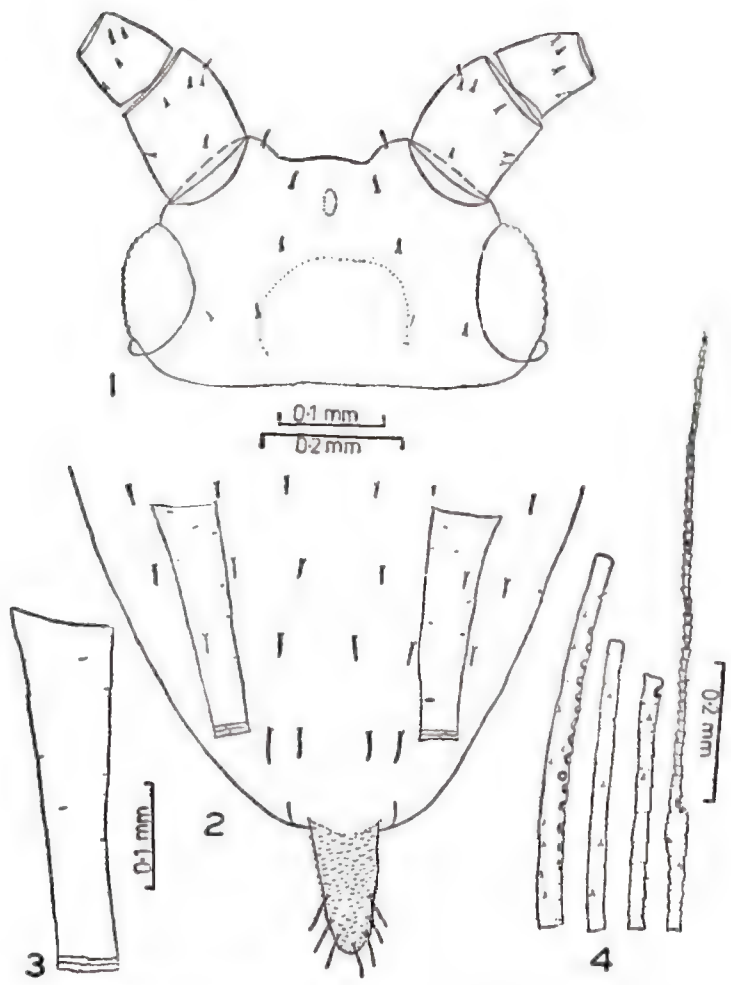
Materials studied : 3 oviparae and 4 nymphs, INDIA, UTTAR PRADESH, Badrinath 13. xi. 1984 (Coll. B. Das) from *Prunus cornuta*; 6 oviparae, 1 alate male and 4 nymphs. Badrinath, 13.xi.1984 (coll. P.K. Medda from *Prunus cornuta*.

Note: Sexuals in the present collection are not accompanied with viviparous forms. The viviparae of this species has characteristic siphunculi which is also present in the sexuals. It makes possible the identification of sexuals. Moreover, viviparae of this species had been collected earlier from the same plant at Badrinath.

Metopolophium simlaensis (Chakrabarti and Raychaudhuri) *Acyrthosiphon* (*Metopolophium*) *simlaensis* Chakrabarti and Raychaudhuri, in Chakrabarti *et al.*, 1974. *Oriental Ins.*, 8:521–530.

Metopolophium simlaensis (Chakrabarti and Raychaudhuri), Eastop and Hille Ris Lambers, 1976. Survey of the World aphids Junk Publishers, p. 279.

Alate viviparous female (Figs. 1–4) : Body about 2.08 mm long and 0.78 mm wide Dorsum of head with 5 pairs of hairs, longest one on vertex about 22 μm long and 0.60 times the b.d. III. Antennae about 1.05 times the body; segments I and II with 6–7 and 4 hairs respectively; segment III with 12–15 non-protuberant secondary rhinaria and longest hair on it about 11 μm long and 0.30 times the b.d. III; p.t. about 3.88 times the base of segment VI and about 1.22 times the segment III. U.r.s. as long as h.t.2 and with 7 secondary hairs. Abdominal dorsum almost smooth, without any sclerotic patch, and with about 8 hairs on anterior tergites, longest hair being about 13 μm long and 0.35 times the mentioned diameter, tergite 7 with 5 hairs, longest hair on this tergite and on 8th tergite about 38 μm and 49 μm long, and 1.05 times and 1.35 times



Figs. 1–4. *Metopolophium simlaensis* (Chakrabarti and Raychaudhuri). Alate viviparous females.
1. Head; 2. posterior portion of abdomen; 3. siphunculus; 4. antennal segments (III – VI).

the b.d.III respectively. Siphunculi smooth with indistinct flange, about 0.17 times the body and about 1.94 times the cauda. Cauda somewhat thinner than that of apterae and with 7 hairs. Subgenital plate with 2 hairs on anterior margin and 12 hairs on posterior margin. Wing venation normal. Other characters as in aptera.

Measurements of the alata in mm: Body length 2.08, width 0.78; antenna 2.18; antennal segments III:IV:V:VI 0.51:0.39: 0.34: (0.16+0.62); u.r.s. 0.12; h.t.2 0.12; siphunculus 0.35; cauda 0.1.8.

Material studied : 1 aptera, 1 alata and 2 nymps, INDIA, UTTAR PRADESH, Mussoorie, 28.x.1977 (coll. S.P. Maity) from *Launea* sp.

ACKNOWLEDGEMENTS

Thanks are due to the Head ofthe Department of Zoology, University of Kalyani, for laboratory facilities.

REFERENCES

CHAKRABARTI, S. & D. K. BHATTACHARYA (1985) Review of *Eumyzus* Shinji (Homoptera : Aphididae) with descriptions of two new species from the Indian region. *Syst. Ent.*, **10**, 387–393.

CHAKRABARTI, S., A. K. GHOSH & D. N. RAYCHAUDHURI (1974) Some new aphids (Homoptera: Aphidae) from Himachal Pradesh, India. *Oriental Ins.*, **8** (4), 521–530.

MEDDA, P. K. & S. CHAKRABARTI (1986) Hitherto unknown alate morphs of two species of *Eumyzus* Shinji (Homoptera : Aphididae) from India with a key to alate viviparous females. *Syst. Ent.*, **11**, 107–110.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 33 to 38

PRELIMINARY STUDIES ON THE SUGARCANE SCALE INSECT *AULACASPIS MADIUNENSIS* (ZEHNTNER)

H. DAVID, V. NANDAGOAL & Y. SOMASEKHARA GOUD
Sugarcane Breeding Institute, Coimbatore, India 641 007

(*Received* 17 *May* 1988)

A brief report on the biology of the sugarcane scale insect *Aulacaspis madiunensis* is given.

(*Key words:* sugarcane scale insect, *Aulacaspis madiunensis*, biology)

More than forty species of scale insects are associated with sugarcane in different cane growing countries of the world (RAO & SANKARAN, 1969). In India, twelve species damage sugarcane in varying proportions. Predominantly, *Melanaspis glomerata* Green inflicts heavy loss both quantitatively and qualitatively. Another species of scale insect, *Aulacaspis madiunensis* (Zehntner) was recorded at Pettavaithalai sugar factory area of Trichy district and also at Coimbatore in Tamil Nadu. This is the first record of this pest in Tamil Nadu. Earlier (RAO & RAO, 1984) this was recorded from Srikakulam district of Andhra Pradesh. This is a pest of significance in Queensland (Australia) (RAO & SANKARAN, 1969). Originally it was reported from Java (ZEHNTNER, 1898) where the loss to grown up cane was heavy. Subsequently, it has spread to Kampala (Uganda) (GOWDEY, 1920). It was also reported from sugarcane and grasses in Formosa (TAKAHASHI, 1940), from *Erianthus arundinaceus* (Retz.) Jeswit in Ceylon (GREEN, 1937) and from the grasses in China (SCTT, 1952).

This species confines its activity only to the sugarcane stem at nodal and internodal regions. In no case, this is found attacking either the leaf lamina or the leaf sheath. A thick white encrustation of scale population occurs on the cane stalk resulting in desapping of canes.

The infested canes with adult scale insects were cut into pieces with two or three internodes and tied to potted sugarcane plants of 6 to 8 months' age. These were covered with polyvinyl sheet cage and wrapped with black cloth. The crawlers emerged at a particular time and settled on fresh internodes and these were marked with marking pen. Settlers of the same age group were marked as test population in separate potted protected plants. In female, different instars were recorded by observing the secretion of waxy coating over the soft body of scale insects. In male, second instar, prepupal, pupal and adult emergence was recorded by dissecting the developing males daily. The preoviposition period was estimated by observing duration between cessation of growth of armour of the III instar and the beginning of oviposition. The oviposition period and fecundity were assessed simultaneously by removing the eggs laid daily by lifting the armour and replacing the same by pinning with No. 20 pin as well as by counting the chorions which accumulate beneath the armour. The eggs collected at different timings were placed separately on a petri-dish provided with moist sponge and filter paper for normal

development. Different instars of both the sexes were noted and collected from the test population in 70 per cent alcohol. Morphometrics of different instars were computed using ocular and stage micrometer.

Males (Fig. 1) though less in number emerge in (Fig. 2) large numbers and mate with adult females. Copulation occurs through the raised armour of the adult female.

Oviposition:

The eggs are laid one by one and accumulate under the armour. The ovipositing female occupies a greater part of the armour and when once egg laying starts the adult shrivels a little. Female lays an average of 129 ± 29.80 eggs.

Egg:

Fresh eggs are shiny but dull brownish and oval in shape. The crawlers hatch out through the terminal end by rupturing the chorion and the egg shells are accumulated under the armour. The incubation period lasts for about 47.40 ± 1.05 h. It measures 0.25 mm in length and 0.10 mm in width.

Crawlers:

The two phases of the first instar (Fig. 3) are the crawlers (motile phase) and the settlers (sedentary phase). Though synchronous hatching of crawlers occurs, the emergence of the crawlers from the armour is one by one. The crawlers move over the cane for a few hours.

Settlers:

The settlers are the crawlers which have successfully inserted their stylet and start feeding. This stage lasts 5.3 ± 0.82 days in female and 5.26 ± 0.75 days in male.

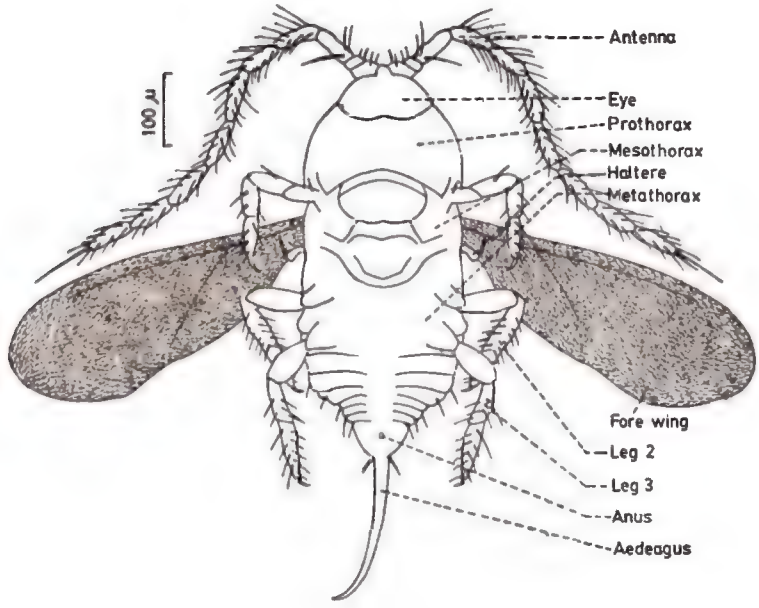


Fig. 1. Adult male

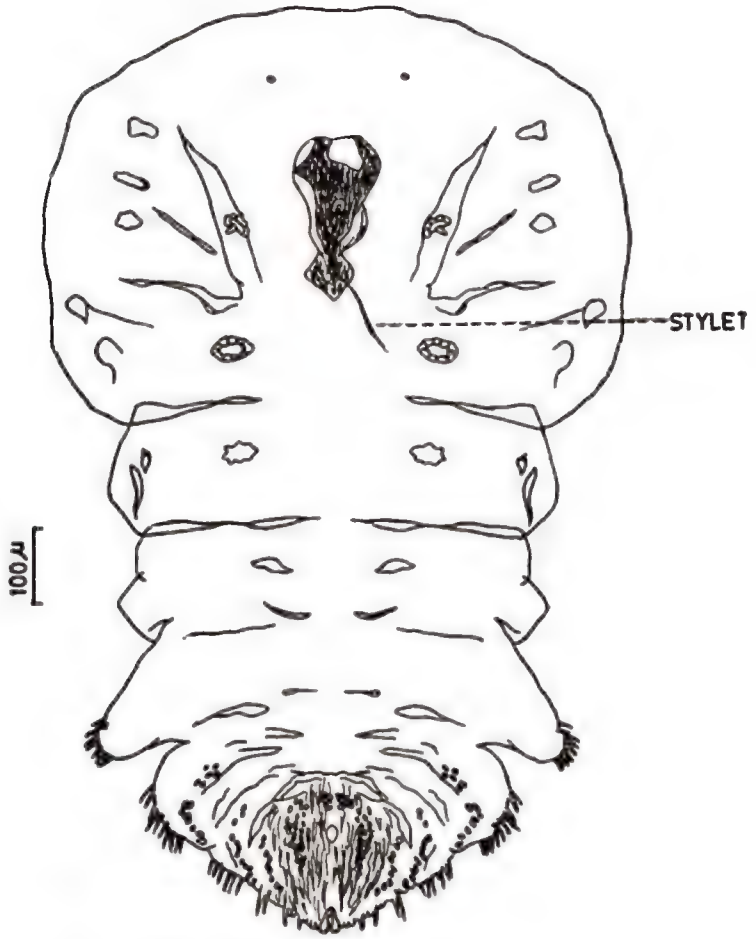


Fig. 2.
Adult ♀

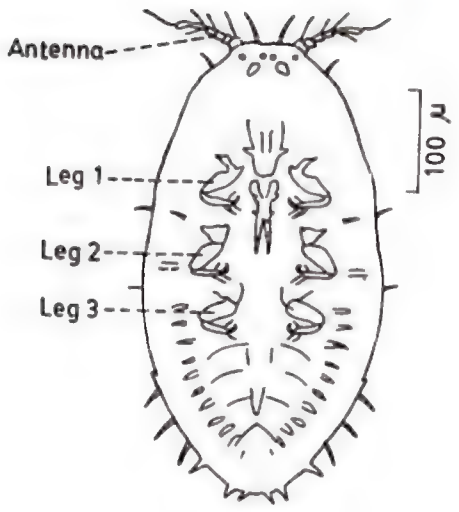


Fig. 3. I Instar

The settlers moult into second instar and at this stage sex could be differentiated clearly. It measures 0.43 mm in length and 0.24 mm in width.

Male:
Second instar (Fig. 4)*:*

The second instar nymphs appear with white cottony armour stretching lengthwise in a parallel manner. It feeds for about 11.83 ± 0.38 days. The length and width of second instar are 0.65 and 0.33 mm respectively. Subsequent instars moult only inside the armour and could not be observed from outside.

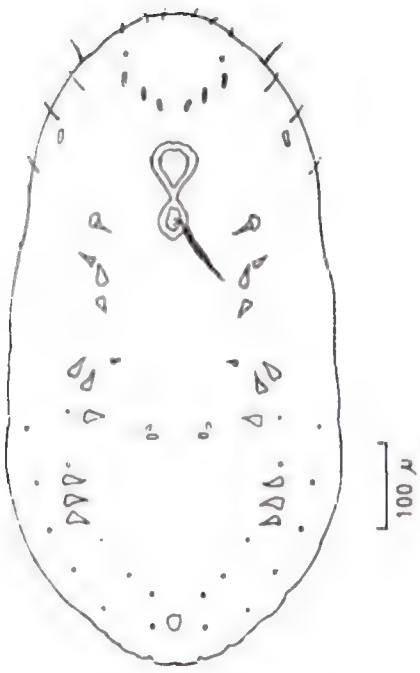


Fig. 4. II Instar ♂

Prepupa (Fig. 5)*:*

This is referred here as prepupa since there was development of rudimentary wing pads and appendages. This stage lasts for about 3.24 ± 0.44 days and measures 0.62 mm in length and 0.18 mm in width.

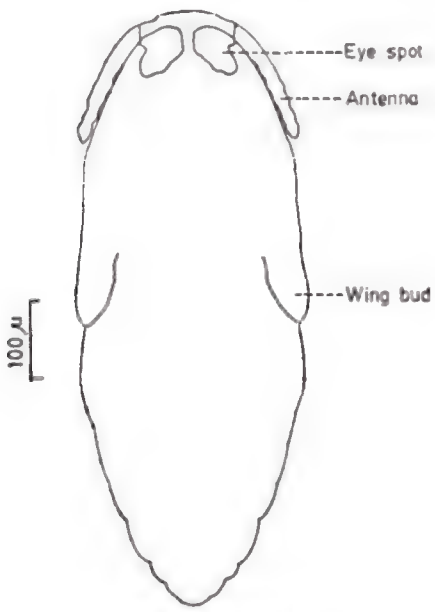


Fig. 5. Prepupa ♂

Pupa (Fig. 6)*:*

The pupa is found to be hyaline at the beginning but later turns reddish in the abdominal region. Wing pads are elongated. A conical stylus develops at the posterior end of abdomen. This stage lasts for 5.5 ± 0.8 days. It measures 0.7 mm in length and 0.20 mm in width.

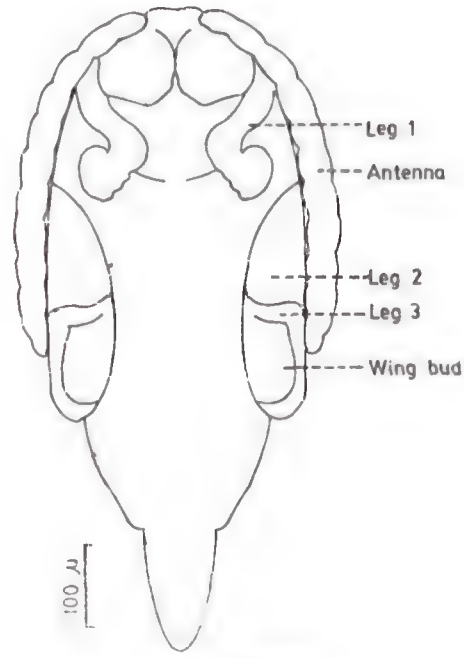


Fig. 6. Pupa ♂

Adult male:

The adult males, which are gnat-like, emerge from the armour by slitting the anterior end dorsally. Male is with reddish abdomen having one pair of glossy white forewings with reduced venation. The hind wings are modified into halteres. Comparatively, a long stylus or male genital sheath is present at the posterior end of the abdomen. Males cannot feed since the

mouth parts are non-functional and vestigial. The only function of the male is to fertilise the female. The longevity of male is 1–3 days (=2±0.77). The length of the male is 0.65 mm and 0.2 mm in width.

Female

Second instar (Fig. 7) :

In the posterior end of the settlers a thin brownish waxy coating extends more or less oval in shape. This stage lasts for 6.90±0.88 days. Following the second moult, the exuvium is not shed but remains in tact. It measures 0.82 mm in length and 0.53 mm in width.

Third instar:

After the second moult, a thin white waxy covering is found extending clearly to a round-shape. The third instar lasts for 21.90±1.45 days. The pinkish adult female lies below the white armour which protects the adult. The preoviposition period lasts for 4.70±0.68 days but the oviposition duration lasts for 7–9 days (8.1±0.57). The adult measures 1.74 mm in length and 0.94 mm in width.

Sex ratio:

Sex ratio 1:0.19 is in favour of females, (female: male).

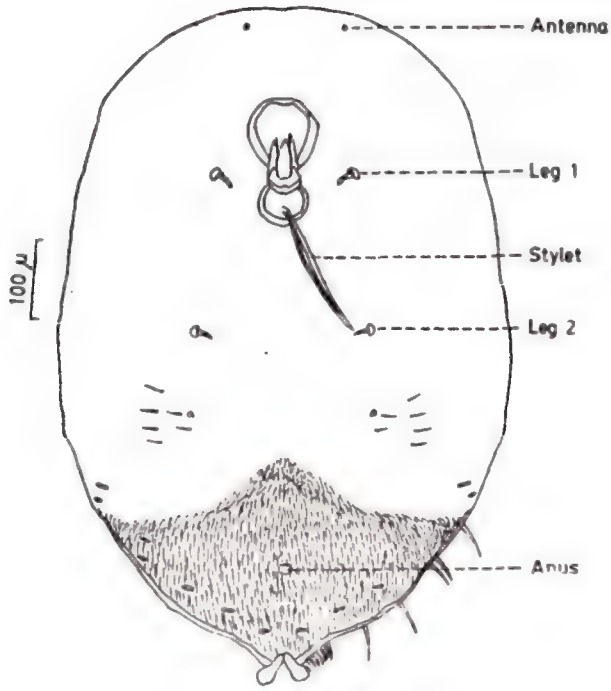


Fig. 7. II Instar ♀

TABLE 1. Life history of *Aulacaspis madiunensis* Zehntner

Particulars	Duration (Mean ± SD)
Incubation period (h)	47.40 ± 1.05
Male	
Ist instar (days)	5.26 ± 0.75
IInd instar (days)	11.83 ± 0.38
IIIrd instar — prepupa (days)	3.24 ± 0.44
IVth instar — pupa (days)	5.07 ± 0.80
Adult	2 ± 0.77
Female	
Ist instar (days)	5.3 0.82
IInd instar (days)	6.90 ± 0.88
IIIrd instar (days)	21.90 ± 1.45
Fecundity (crawlers/female) — Mean (days)	129 ± 28.80

REFERENCES

GREEN, E. E. (1937) An annotated list of the Coccidae of Ceylon, with amendations and additions to date. *Ceylon J. Sci. (B).*, **20**, 277–341.

RAO, A. V. & T. R. RAO (1984) Occurrence of *Aulacaspis madiunensis* Zehntner on sugarcane in India. *Indian J. agric. Sci.*, **54**, 512.

RAO, V. P. & T. SANKARAN (1969) The scale insects of sugarcane, 325–342, *in: Pests of Sugarcane* (Ed. WILLIAMS, J. R., J. R. METCALFE, R. W. MUNGOMERY & R. MATHES) Elsevier Pub. Co., Amsterdam.

SCOTT, C. L. (1952) The scale insect genus *Aulacaspis* in Eastern Asia (Homoptera: Coccidea: Diaspididae). *Microentomology*, **17**, 33–60.

TAKAHASHI, R. (1940) Some Coccidae from Formosa and Japan (Homoptera). V. *Mushi*, **13**, 18–28.

ZEHNTNER, L. (1898) De Plantinluizen van het suikerriet op Java. V. *Chinaspis madiunensis* n. sp. VI. *Chionaspis tegalensis* n. sp. VII. *Chinaspis sepc.* V. Meded. *Proefstn. Oost Java* (n. s.) **37**, 35–40.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 39 to 43

A NEW SPECIES OF GENUS *PATANIA* MOORE (LEPIDOPTERA : PYRALIDAE : PYRAUSTINAE) FROM INDIA

H. S. Rose & A. P. Singh
Department of Zoology, Punjabi University, Patiala, Punjab, India 147 002

(*Received* 17 *May* 1988)

***Patania jatingaensis* sp. n. is described from seven males and one female captured during 1983-1986 from India. The genus *Patania* Moore is reinstated and restricted for the type-species (*Botys concatenalis* Walker) besides the new species, at the moment.**

(*Key words:* new *Patania* species, Pyralidae)

The generic name *Patania* Moore has been considered as one of the synonyms under the genus *Sylepta* Hübner (corrected as *Syllepte* Hübner, Munroe 1968) by Hampson (1896, 1898) and Klima (1939). As per authors' concept of this genus along with its supposed synonymy of twenty four generic names, Munroe (1976) has rightly pointed out it as a waste basket genus. During the course of present studies, eight individuals of an unnamed Pyraustine species, collected from Assam and Arunachal Pradesh (India) tend to fall under the genus *Syllepte*. The identity of this species, as new, is established from the study of relevant literature and its comparison with the reference collections at National Museums and at British Museum (Natural History) London. The species is, accordingly named as *jatingaensis* sp. n. Further the comparison of the genitalia of the new species with the type-species i.e., *Botys concatenalis* Walker 1888 (first described on the basis of a female collected from Darjeeling, India) of the genus *Patania* reveals that they are clearly congeneric as far as the structures such as uncus, saccus and valva ofthe male and ovipositor lobes and apophyses of the female genitalia are concerned. Besides, the fact is also corroborated on their external appearance. In latter respect, it differs from *Syllepte incomptalis* Hübner (Zutrage Samml. exot. Schmett, 2 : 18, pl. 50, figs. 185, 186 : 1823) which is the type-species of the genus *Syllepte*. Keeping in view the existing complexities of the latter genus and the congeneric relationship of the species, under reference, it is suggested that the genus *Patania* be reinstated and be restricted for the type-species and *jatingaensis* sp. n. The proposed arrangement has also been discussed with Mr. Shaeffer (during visit/personal correspondence) of BM (NH) London, where the holotype of the new species is deposited.

GENUS *PATANIA* Moore

Moore, 1888 in Hewitson and Moore, Desc. new Indian Lepid. Insects Coll. late Mr. W. S. Atkinson (3) : 209.

Patania jatingaensis sp. n.

The description of the new species is as follows: Adult (Fig. 1): head, thorax, tegula and patagium shining grey; labial palpus upturned, first segment with a fuscous band in the middle, second segment with few yellow scales at base but largely covered with fuscous scales, third segment short, partly hidden, fuscous scaled; maxillary palpus moderately developed, dilated, base

and dilated portion yellow, with fuscous band in middle; proboscis quite large, with fuscous and yellow scales at base; antenna filiform, slightly shorter than forewing beset with dark scales basally otherwise ochreous and ciliated below; eye fuscous, with a row of yellow scales behind. Forewing with ground color fuscous, black band at base, followed by yellow scales behind, antemedial band dark black, extending from costal margin to inner margin, followed by a small triangular yellow patch, the latter broad and continuous with costal margin, a post medial more or less triangular bright yellow patch, quite conspicuous, extend from costal margin to Cu1 below, a prominent dark black band on outside, with a poorly defined ochreous line bounding it, outer area broadly fuscous; cilia fuscous; under surface with posterior area below anal vein beset with white scales. Hindwing more or less uniformly fuscous, costal margin greyish white basally, a distinct yellow spot present in cell, an indistinct ochreous medial line from below spot to anal angle, cilia on anal area moderately long. Legs long, covered with yellow scales, with fuscous bands at joints, meso- and meta legs with outer tibial spurs about one-third the length of inner ones. Abdomen fuscous, banded with shining scales dorsally, third segment with two prominent dark spots.

Venation (Figs. 2, 3): Forewing with discal cell less than half the length, closed, Sc reaching beyond middle of R_1, the latter not touching the costal margin, R_1 arising from two-thirds the discal cells, R_2 from slightly before anterior angle of cell, R_3 and R_4 stalked, stalk approximated to R_2, R_5 somewhat apposed to R_{3+4}, M_1 almost straight, M_2, M_3 and Cu_1 from posterior angle of cell, 2A present, 3A arched with 2A at base, arch slightly indistinct distally. Hindwing with cell open, less than half the length, Rs fused with the $Sc+R_1$ for some distance beyond cell, stalk of Rs and M_1 extended into the cell, M_2, M_3 and Cu_1 briefly approximated basally, three anals present.

Genitalia (male, Figs. 4, 5): Uncus short, more or less triangular, slightly downcurved distally, moderately sclerotized, completely bare; tuba analis present, much longer than uncus, subscaphium conspicuous, streak like; tegumen broad, produced mid-ventrally into short finger-like processes; vinculum short; saccus subrounded and reduced; valva leaf like, membranous, costa and sacculus well sclerotized basally, harpe present, thorn-like, originating from a sclerotized patch; transtilla with each half strap-like, moderately sclerotized otherwise well developed; juxta somewhat rectangular in shape, slightly notched anteriorly; aedeagus long and slender, ductus ejaculatorius simple, entering at top, vesica simple, with a sclerotized patch, armed with numerous short dents/spines, the latter densely and irregularly arranged.

Female (Fig. 6): Ovipositor lobes broad, finely setosed with equal sized setae; posterior apophysis weak, shorter than anterior ones, the latter comparatively well developed, each with its base pointed, swollen, more or less angular; ostium bursae with genital plate present, the latter shield-like and well defined; ductus bursae long, almost membranous throughout; corpus bursae spherical and bag-like; scaphium represented by a sclerotized area.

Wing expanse: Male : 42 mm.
Female : 40 mm.

Distribution: At present known from India

Material examined:

Holotype, ♂, India, Assam, Khasis Hills (N. E. India), 23. ix. 1983. male genitalia slide number assigned by BM (NH) 17461

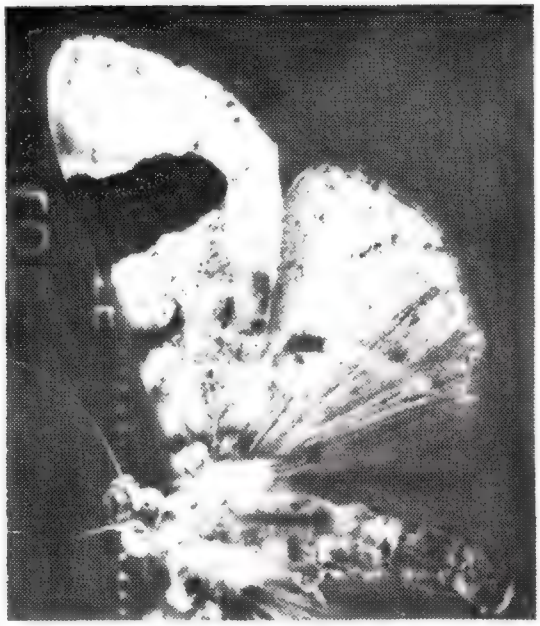
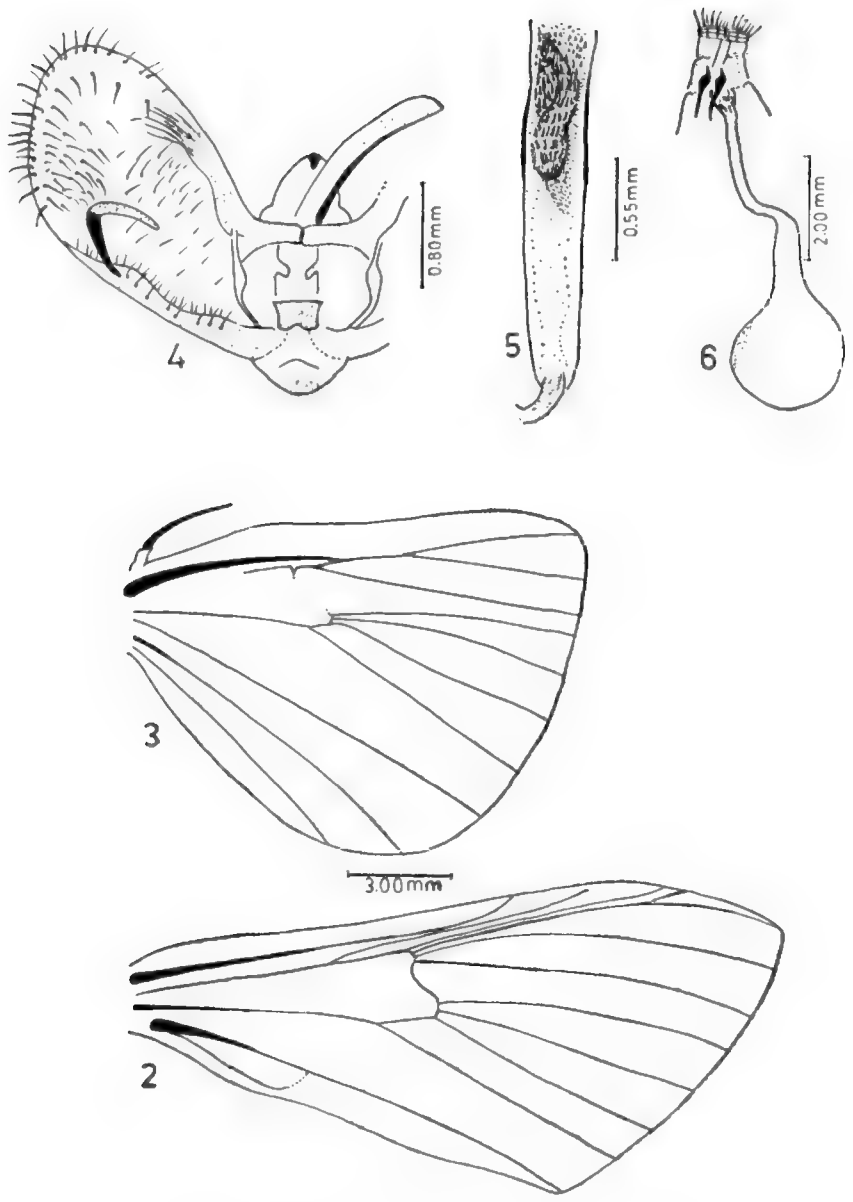


Fig. 1. *Patania jatingaensis:* photograph of the adult.



Patania jatingaensis sp. n. : Figs. 2, 3: fore and hindwings; Figs. 4, 5: male genitalia; Fig. 6: female genitalia.

(deposited in British Museum (Natural History) London.

Paratypes, 3♂, Assam, Haflong: Jatinga, 3.ix.1983 and 14.ix.1983; 2♂, same locality, 13.ix.1985 and 15.ix.1985; 1♂, I♀, India, Arunachal Pradesh, Tirap, Deomali, 31. viii.1986 and 4.ix.1986. (Deposited in the Department of Zoology, P. U. Patiala (Punjab : India).

Note: One paratype has also been deposited in BM (NH) London.

Life history: Unknown

The species is named after one of the localities i.e., Jatinga (Haflong: Assam) which is surrounded by mountains of U-shape. It may be added that the locality is unique due to the occurrence of a phenomenon called "Mass Suicide" by birds, attracted to artifical light fixed on a watch tower. The altitude of the place is about 5000 feet from above the sea level and the place is about 150 km away from the Bay of Bengal.

KEY TO THE SPECIES OF THE GENUS *PATANIA* MOORE

Adult with ground colour fuscous brown, the latter with cuperous tinge; hindwing without any speck anywhere; aedeagus with cornutus well developed, spine-like, long ..... *concatenalis* Walker

.....Adult with ground color fuscuous black; hindwing with a prominent yellow speck in the cell; aedeagus with vesica armed with numerous dents/spines, arrnanged on a sclerotized patch, representing cornutus.... ..... *jatingaensis* sp. n.

ACKNOWLEDGEMENTS

The senior author wishes to thank DR. GADEN S. ROBINSON and MR. M. SHAEFFER of the British Museum (Natural History) London for the help rendered by them during his visit to the museum. The comments by MR. SHAEFFER made the preparation of this manuscript possible. The financial assistance rendered by the University Grants Commission, New Delhi (Government of India) is acknowledged heartily.

REFERENCES

HAMPSON, G.F.(1896) Fauna of British India(Moths), Vol. 4. 33+594, 287 text figs. London, Berlin. Bombay, Calcutta.

HAMPSON, G. F. (1898) A revision of the moths of the subfamily Pyraustinae and family Pyralidae. Part II. *Proc. Zool. Soc. London*, 590–761.

KLIMA, A. (1939) Lepidoptrum Catalogus, Pyralidae: Subfam., Pyraustinae. **89 & 94**, 1–384. S. Gravenhage.

MUNROE, E. (1968) New species of *Apilocrocis* with a key to known species (Lepidoptera: Pyralidae). *Can. Ent.*, **100**, 441–448.

MUNROE, E. (1976) New genera and species of Pyraustinae (Lepidoptera: Pyralidae), mainly from the collection of British Museum (Natural History). *Can. Ent.*, **108**, 873–884.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 45 to 48

EFFECT OF BHC ON ACID - AND ALKALINE PHOSPHATASE ACTIVITY IN LARVAE OF *LEUCOPHOLIS LEPIDOPHORA* BL.

S. P. GOVINDWAR & G. P. BHAWANE[1]

Biochemistry Division, Department of Chemistry, Shivaji University, Kolhapur, India 416 004

(*Received* 17 *May* 1988)

Effect of BHC (1.5 and 3.0 g of 10% BHC in 1 m × 1 m × 10 cm volume of soil) on acid and alkaline phosphatase activities in different instar larvae of *Leucopholis lepidophora* Bl. has been investigated. The activity of acid phosphatase was comparatively higher than the alkaline phosphatase. A significant increase in 2000 × g supernatant protein was observed due to BHC treatment in IIIrd instar larvae. However, no significant change was observed in 1st and IInd instar larvae. BHC treatment showed decrease in both phosphatase activity; however, alkaline phosphatase increased significantly in Ist instar larvae. Overall pattern of inhibition of activity due to BHC was dose dependent.

(*Key words:* BHC, acid phosphatase, alkaline phosphatase)

INTRODUCTION

The important function of pohsphatases in various physiological processes of insects such as nutrition, egg maturation and intermediate metabolism (LUDWIG et al., 1962) growth, metamorphosis and development (ASHRAFI & FISK, 1961; HODGSON, 1963; EGUCHI, 1965; SRIVASTAVA & SAXENA, 1967; SUJAK, 1977; VERKUIL, 1978; HEGDE & KRISHNAMURTHY, 1980; MATHAI & NAIR, 1982) has been investigated. Lysosomal nature of the acid – and alkaline phosphatases, and the levels of enzyme activity in different age houseflies (BARKER & ALEXANDER, 1958) and during metamorphosis of *Musca domestica* (HEGDEKAR & SMALLMAN, 1967) has been reported earlier. Our knowledge on the changes in the activity of acid – and alkaline phsophatases due to pesticidal action is very scanty. Therefore, the present studies were planned to understand the effect of BHC on the acid – and alkaline phosphatase activity in *Leucopholis lepidophora* Bl. in different larval stages.

[1]Address for correspondence:
Department of Zoology, Shivaji University, Kolhapur, India 416 004

MATERIALS AND METHODS

The different instar larvae of *L. lepidophora* Bl. were collected from the sugarcane fields of Sangrool, Dist. Kolhapur, Maharashtra. The larvae were grouped into three different instars on the basis of their body size and width of head capsules. The larvae with approximately similar weight of respective instars have been grouped for BHC treatments. Two concentrations of 10% BHC were prepared by thorough mixing of 1.5g and 3 g of 10% BHC in known volume (1m × 1 m × 10 cm) of soil. Soil was sufficiently moistend with tap water and filled in earthen pots. The larvae were divided into 9 groups containing 10 larvae in each group. Group 1, 4 and 7 served as controls of I, II and III instar larvae, respectively. Group 2, 5 and 6 of I, II and III instar laravae respectively, were lodged in earthen pots containing 1.5 g of 10% BHC in soil. Group 3, 6 and 9 of I, II and III instar larvae were lodged in earthen pots containing 3.0 g of 10% BHC in soil for 18 h.

The larvae were taken out after treatment, washed thoroughly with water, weighed

carefully after removing rectal content, blotted dry and homogenised with teflon pestle in 0.25 M sucrose solution. The homogenate was centrifuged at 2000 × g for 10 min to remove cell debris. Aliquots of supernatant were used for determination of phosphatase activity. Assay of phosphatases were carried out according to procedure of EGUCHI et al. (1972) measuring the rate of hydrolysis of *p*-nitrophenyl phosphate. Acid phosphatase and alkaline phosphatase activity were determined at pH 4.8 (citrate buffer) and pH 10 (carbonate bicarbonate buffer) respectively. 2000 × g supernatant protein was estimated by biuret method (GORNALL et al., 1949). Statistical analyses were carried out using Student t-test (OSTLE, 1966).

RESULTS AND DISCUSSION

The results of various estimations regarding acid- and alkaline phosphatase activities in relation to two different concentrations of 10% BHC in three larval instars are given in Table 1.

BHC treatment in soil showed considerable loss in larval body weight due to the reduction of moisture content of the body. Larval 2000 × g supernatant protein significantly increased by 20% and 50% due to 1.5 g and 3 g of 10% BHC treatment, respectively, in IIIrd instar larvae. However, no significant change was observed in Ist and IInd instar larvae. Increase in the level of body protein was also recorded during DDT and malathion treatment in *Periplaneta americana* (RAMALINGAM, 1986).

The activity of acid phosphatase was very high, compared to the alkaline phosphatase activity in all groups. Similar observations were made in *Callosorbuchus analis* (DHAND & RASTOGI, 1975) and in *Spodoptera mauritia* (MATHAI & NAIR, 1984). Third instar larvae of *L. lepidophora* Bl. showed more acid- and alkaline phosphatase activity

TABLE 1. Effect of BHC on acid-and alkaline puosphatase activity in *Leucopholis lepidophora* Bl. in different larval stages.

Larval stage	Treatment	mg of protein/g tissue	Acid phosphatase +	Alkaline phosphatase +
Ist Instar	Control	23.87 ± 0.50	3.90 ± 0.25	0.16 ± 0.020
	T1	25.55 ± 0.55	2.87 ± 0.15*	0.23 ± 0.010*
	T2	25.43 ± 0.50	2.47 ± 0.20*	0.23 ± 0.015*
IInd Instar	Control	32.14 ± 0.70	2.40 ± 0.10	0.27 ± 0.010
	T1	26.07 ± 0.50**	2.16 ± 0.15	0.24 ± 0.020
	T2	32.24 ± 0.25	2.09 ± 0.10	0.22 ± 0.010*
IIIrd Instar	Control	20.36 ± 0.50	4.62 ± 0.25	0.23 ± 0.01
	T1	24.39 ± 0.25**	2.89 ± 0.30*	0.11 ± 0.015**
	T2	30.46 ± 0.65**	2.23 ± 0.15**	0.09 ± 0.020**

+ = μg of *p*-nitrophenol liberated/min/mg protein.

T1 1.5 g of 10% BHC in known volume (1 m × 1 m × 10 cm) soil.

T2 3.0 g of 10% BHC in known volume (1 m × 1 m × 10 cm) soil.

Values are mean of 3 experiments ± SE, 10 larvae in each group. Those marked with asterisks differ significantly from the controls: * $P < 0.05$, ** $P<0.01$ (by Student t-test).

as compared to I instar larvae. This may be due to less activeness of I instar larvae and more activeness of III instar larvae, which results in the accumulation of reserve food viz. glycogen, proteins and fat bodies (WAYTT, 1961; CHIPPENDALE, 1970) and ultimately increase in the phosphatase activity in III instar larvae.

Acid phosphatase activity showed a significant decrease due to 1.5 g and 3 g of 10% BHC treatment to larvae in all treated groups. 3 g of 10% BHC treatment showed higher inhibition of phosphatase activity as compared to 1.5 g of 10% BHC treatment. It indicates the inhibition of acid phosphatase is dose dependent.

A significant decrease in alkaline phosphatase activity was observed in II and III instar larvae; however, significant increase (of 43%) in phosphatase activity was observed in I instar larvae.

These changes in the activity of acid and alkaline phosphatase indicates the inhibitory action of BHC on lysosomal enzymes. The III instar larvae of *L. lepidophora* Bl. are more susceptible to BHC than the I and II instar larvae.

ACKNOWLEDGEMENT

The authors are thankful to Mr. R. K. BHANOT for his help during this study. One of us (GPB) is thankful to CSIR for financial assistance.

REFERENCES

ASHRAFI, S. H. & F. W. FISK (1961) Phosphatase activity in different life cycle stages of the stable-fly *Stomoxys calcitrans* (L). *Pak. J. Sci. Ind. Res.*, **4**, 70–73.

BARKER, R. J. & B. H. ALEXANDER (1958) Acid and alkaline phosphatase in houseflies of different ages. *Ann. ent. Soc. Am.*, **51**, 255–257.

CHIPPENDALE, G. M. (1970) Metamorphic changes in haemoloymph and midgut proteins of the South-western corn borer *Diatraea grandiosella*. *J. Insect Physiol.*, **16**, 1909–1920.

DHAND, R. K. & S. C. RASTOGI (1975) Acid and alkaline phosphatase activity in relation to egg laying and ageing in *Callosobruchus analis* (Fab.) (Coleoptera : Bruchidae). *Can. J. Zool.*, **53**, 1500–1504.

EGUCHI, M. (1965) Changes in phosphatase in the silkworm, *Bombyx mori* L. during development. *Bull. Kyoto Univ. Indust. Arts and Text. Fib.*, **4**, 351–355.

EGUCHI, M., M. SAWARI & Y. SUZUKI (1972) Multiple forms of midgut alkaline phosphatase in the silkworm: separation and comparison of two isozymes. *Insect Biochem.*, **2**, 167–174.

GORNALL, A. G., C. J. BARDWILL & M. M. DAVID (1949) Determination of serum proteins by means of the biuret reaction. *J. biol. Chem.*, **177**, 751–766.

HEGDE, S.N. & N.B. KRISHNAMURTHY (1980) Ontogenetic differentiation of allkaline and acid phosphatases in two races in silkwarm – *Bombyx mori* (L). *The Ind. Zoologist*, **4**, 27–32.

HEGDEKAR, B. M. & B. M. SMALLMAN (1967) Lysosomal acid phosphatase during metamorphosis of *Musca domestica* (Linn.). *Can. J. Biochem.*, **45**, 1202–1206.

HODGSON, E. (1963) Alkaline phosphomonoesterase activity in insects. 2. Activity in various cell fractions from the blowfly, *Phormia regina* (Meig.). *Ann. ent. Soc. Am.*, **57**, 613–617.

LUDWIG, D., C. FLORE & C. R. JONES (1962) Physiological comparison between offspring of the yellow meal worm, *Tenebrio molitor*, obtained from young and from old parents. *Ann. ent. Soc. Am.*, **55**, 439–442.

MATHAI, S. & V. S. K. NAIR (1982) Levels of phosphatases during pupal – adult transformation in *Spodoptera mauritia* Bouisd. (Lepidoptera Noctuidae). *Entomon*, **7**, 311–313.

MATHAI, S. & V. S. K. NAIR (1984) Effects of a juvenile hormone analogue on acid and alkaline phosphatase activities in the pupae of *Spodoptera mauritia* Bouisd. (Lepidoptera: Noctuide). *Comp. Physiol. Ecol.*, **9**, 253–256.

OSTLE, B. (1966) *Statistics in Research*. 2nd Ed. 119 pp. Oxford and IBH Publishing Co.,

RAMALINGAM, K. (1984) Insecticidal action of pesticides on *Periplaneta americana*: Effects of DDT and malathion. *IIIrd Oriental Ent. Symp. Proc.*, Pt. **2**, 55–59.

SRIVASTAVA, J. P. & S. C. SAXENA (1967) Studies on the alkaline and acid phosphatase in the alimentary tract of *Periplanata americana*. *Appl. Ent. Zool.*, **2**, 85–92.

SUJAK, P. (1977) The activity of acid and alkaline phosphatase during the development of the beet army worm (Lepidoptera: Noctuidae). *Bull. Soc. Aus. Sci. Let. Poznan. IZ* 124–128.

VERKUIL, E. V. P. (1978) Increase in acid phosphatase activity in the fat bodies during larval and pharate pupal devlopment in *Calliphora erythrocephala*. *J. Insect Physiol.*, **24**, 375–382.

WYATT, G. R. (1961) The Boichemistry of insect haemolymph. *A. Rev. Ent.*, **6**, 75–102.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 49 to 51

DEVELOPMENT OF THE ENCYRTID PARASITOID *ANAGYRUS DACTYLOPII* (HOW.) ON THE GRAPE MEALYBUG *MACONELLICOCCUS HIRSUTUS* (GREEN)

M. MANI & T. S. THONTADARYA
Biological Control Laboratory I
Division of Entomology and Nematology
Indian Institute of Horticultural Research, Bangalore, India 560 089

(*Received* 17 *May* 1988)

The encyrtid, *Anagyrus dactylopii* (How) is the dominant parasitoid of the grape mealybug, *Maconellicoccus hirsutus* (Green) in South India. A study on the development of the parasitoid on different stages of the mealybug indicated that the parasitoid was able to complete the development on all stages of the mealybug. Development of the parasitoid decreased slightly with the increase in the age of the mealybug. Higher percentage of parasitism and more female progeny production were observed when 3rd instar and adult female mealybug were exposed to the parasitoid. It is concluded that these two stages of *M. hirsutus* are more suitable to breed *A. dectylopii*.

(*Key words:* Encyrtid, parasitod, *Anagyrus dactylopii*, mealybug, *Maconellicoccus hirsutus*)

INTRODUCTION

The pink mealybug *Maconcellicocus hirsutus* (Green) is a polyphagous pest infesting more than 125 plant species. It is especially severe on grapevine in South India. An encyrtid *Anagyrus dactylopii* (How.) was found parasitising the mealybug to an extent of 70 per cent around Bangalore (MANI *et al.*, 1987). Since not much information on this important parasitoid was available, a study was designed to determine the host stage suitable for the breeding of *A. dactylopii*.

MATERIALS AND METHODS

Culture of *M. hirsutus* was maintained on pumpkin fruits in the laboratory as outlined by CHACKO *et al.* (1978) for *Planococcus citri* (Risso). Adult parasitoids were obtained from the cages in which mealybug grape bunches were kept.

About 400 mealybugs were maintained on each ripe pumpkin kept in a wooden cage (30 × 30×30 cm). Pumpkins containing 1st instar, 2nd instar, 3rd instar female nymph and adult female mealybug were exposed separately to 100 mated female parasitoids for a period of 24 h in wooden cages. Based on emergence of adults, the developmental period of the parasitoid on each stage of the mealybug was worked out. Percent parasitism due to *A. dactylopii* in each stage of the mealybug was calculated by counting the number of parasitised and unparasitised mealybugs at the end of the experiment which was replicated five times. Sex ratio of the parasitoid was worked out with the adults that emerged from each exposed mealybug stage.

RESULTS AND DISCUSSION

During the study period, the temperature ranged from 27 to 29°C and the relative humidity from 60 to 65 percent in the laboratory.

Contribution No. 99/88 of I.I.H.R., Bangalore.

Developmental period :

A. dactylopii was able to complete its development on all three nymphal stages and adult female of *M. hirsutus*. The duration of parasitoid development decreased slightly with the increase in the age of the mealybug in the present study. Similar results were obtained by AVIDOV *et al.* (1967) and CHANDLER *et al.* (1980) for *Anagyrus pseudococci* (Girault). Pooled mean developmental time for male and female of *A. dactylopii* on 1st, 2nd, 3rd nymphal and adult stage of the female mealybug was 14.5, 13.8, 13.3 and 13.2 days respectively. However the differences in the duration of parasitoid development on various stages of the mealybug were not statistically significant (Table 1). The delay in the development of the parasitoid when the young nymph was attacked, has been earlier reported for *Anagyrus kamali* Moursi (MOURSI, 1948), and *Anagyrus indicus* Shafee (NECHOLS & KIKUCHI, 1985).

Per cent parasitism :

The age of the mealybug influenced significantly the rate of parasitisation by *A. dactylopii*. The highest parasitism of 81.11% was observed when the adult female mealybugs were exposed to the parasitoid, and it was 74.30 per cent on third instar female nymphs. The present finding is in agreement with CHANDLER *et al.* (1980) who observed the highest per cent parasitism of 67.8 when third instar female nymph of *P. citri* was exposed *A. pseudococci*. The preference of adult female mealybug *M. hirsutus* by *A. dactylopii* is in agreement with RIHERD (1950) who found *Anagyrus antoninae* Timberlake preferring the gravid female mealybug *Antonia graminis* (Maskell).

Sex ratio :

Production of male and female progeny in the parasitoid was highly influenced by the age of the mealybug used for parasitisation. Male parasitoid progeny decreased with the increase in age of the mealybug but that of the female progeny increased with the increase in the age of the mealybug. Parasitisation of the first and second nymphal stages of the host resulted in mostly males whereas more female parasitoids emerged from the parasitised third instar nymphs and adult female mealybugs (Table 1). Similar results were observed by AVIDOV *et al.* (1967) and

TABLE 1. Developmental period, parasitism and sex ratio of *Anagyrus dactylopii* in relation to the stage of *Maconellicoccus hirsutus* parasitised.

Host stage	Development of the parasitoid (days)	Per cent parasitism	Sex ratio (male: female)
First instar (5 days old)	14.50 ± 0.53	1.21 (6.09)	1 : 0.07
Second instar (10 days old)	13.80 ± 0.42	34.34 (35.82)	1 : 0.34
Third instar (15 days old)	13.30 ± 0.48	74.30 (59.71)	1 : 1.89
Adult female (22 days old)	13.20 ± 0.43	81.11 (64.34)	1 : 2.85
C D (P = 0.05)	Non significant	4.08	..

CHANDLER *et al.* (1980) with *A. pseudococci*, and NECHOLS & KIKUCHI (1985) with *A. indicus*. It may be concluded that the third instar and adult female mealybug are highly suitable for the breeding of *A. dactylopii*.

ACKNOWLEDGEMENTS

The authors are thankful to Director, I I H R for providing facilities to conduct the study.

REFERENCES

AVIDOV, Z., Y. ROSSLER & D. ROSEN (1967) Studies on an Israel strain of *Anagyrus pseudococci* (Girault) (Hym., Encyrtidae). II. Some biolgical aspects. *Entomophaga*, **12**, 111–118.

CHACKO, M. J., P. K. BHAT, L. V. ANAND RAO, M. B. SINGH, E. P. RAMANARAYAN & K. SREEDHARAN (1978) The use of the lady bird beetle *Cryptolaemus montrouzieri* for the control of coffee mealybugs. *J. Coffee Res.*, **8**, 14–19.

CHANDLER, L. D., D. E. MEYERDIRK, W. G. HART & R. G. GARCIA (1980) Laboratory studies on the development of the parasite, *Anagyrus pseudococci* (Girault) on insectary reared *Planococcus citri* (Risso). *South West. Ent.*, **5**, 99–103.

MANI, M., T. S. THONTADARYA & S. P. SINGH (1987) Record of natural enemies on the grape mealybug, *Maconellicoccus hirsutus* (Green). *Curr. Sci.*, **56**, 624.

NECHOLS. J. R. & R. S. KIKUCHI (1985) Host selection of the spherical mealybug (Homoptera: Pseudococcidae) by *Anagyrus indicus* (Hym., Encyrtidae) — Influence of host stage on parasitoid oviposition, development, sex ratio and survival. *Environ. Ent.*, **14**, 32–39.

RIHERD, P. T. (1950) Biological notes on *Anagyrus antoninae* Timberlake (Hym., Encyrtidae) and its host, *Antonina graminus* (Maskell) (Homoptera, Coccidae). *Fla Ent.*, **83**, 18–22.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 53 to 57

A NEW TERMITE OF GENUS *MICROTERMES* (ISOPTERA: MACROTERMITINAE) FROM RAJASTHAN, INDIA

N. S. RATHORE
Desert Regional Station, Zoological Survey of India,
Paota 'B' Road, Patodi House, Jodhpur (Rajasthan), India

(*Received* 17 *May* 1988)

A new species of genus *Microtermes* Wasmann (Isoptera: Macrotermitinae) is described from Rajasthan.

(*Key Words:* new species, *Microtermes*, *Rajasthan*)

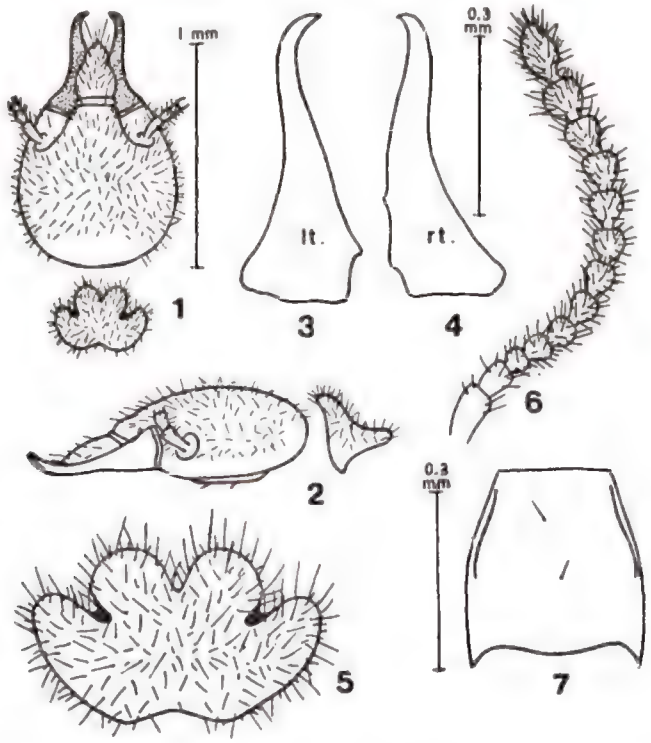
Material :

One vial with 4 soldiers and many workers in spirit, from agriculture field, *ca.* 5 km North–West of Kumher Tehsil, District Bharatpur, Rajasthan coll. N. S. Rathore, 20.vi.1983. *Ex.* Dry grass stems.

Microtermes bharatpurensis sp. nov. (Fig.1–3)

Imago: Unknown.

Soldier: (Fig. 1; Table 1). Head brownish yellow, mandibles reddish brown, slightly paler basally, postclypeus and labrum pale yellow, rest of the body whitish yellow. Head sparsely, abdomen moderately pilose.



Microtermes bharatpurensis n. sp. (Rathore). Soldier from Rajasthan ; Bharatpur, agriculrure field *ca.* 5 km NW of Kumher. (1) Head and pronotum in dorsal view; (2) Ditto, side view; (3) Left mandible in dorsal view; (4) Right mandible; (5) Pronotum in dorsal view enlarged; (6) Right side antenna enlarged; (7) Postmentum in situ enlarged. lt. left mandible; rt. right mandible.

TABLE 1. Body measurements (in mm) of 4 solders of *Microtermes bharatpurensis* sp. nov.

Body parts	Range	Holotype
1. Total body-length *ca.*	2.39–2.50	2.47
2. Head-length with mandibles	1.13–1.18	1.13
3. Head-length to lateral base of mandibles	0.68–0.70	0.68
4. Maximum width of head	0.68–0.71	0.70
5. Maximum height of head	0.50–0.52	0.50
6. Length of labrum	0.23–0.24	0.23
7. Maximum width of labrum	0.17–0.18	0.18
8. Length of mandibles		
(a) Left mandible	0.45–0.47	0.45
(b) Right mandible	0.45–0.47	0.45
9. Head-mandibular index (Left mandible length/ head length to base of mandible)	0.66–0.67	0.66
10. Maximum length of postmentum	0.34–0.36	0.36
11. Maximum width of postmentum	0.32–0.34	0.33
12. Number of antennal segments		
(a) Left antenna	13	5(Broken)
(b) Right antenna	13	13
13. Maximum length of pronotum	0.28–0.30	0.28
14. Maximum width of pronotum	0.42–0.43	0.42

Total body-length *ca.* 2.47 mm.

Head: Head-capsule broadly oval; almost as long as broad; broadest near the posterior region; distinctly convergent anteriorly; posterior margin convex. *Antennae:* with 13–segments; segments 1 and 2 sparsely and remainder moderately pilose; 1st longest and cylindrical: 2nd about half of 1; 3rd shortest; 4th to penultimate gradually increasing in length and becoming club-shaped; apical segment (13) ovate.

Labrum: lancet shaped, widest in the basal half, sides arched, distinctly narrowing anteriorly; apical portion narrower and pointed in front; beset with a few long and short hairs on the tip and body.

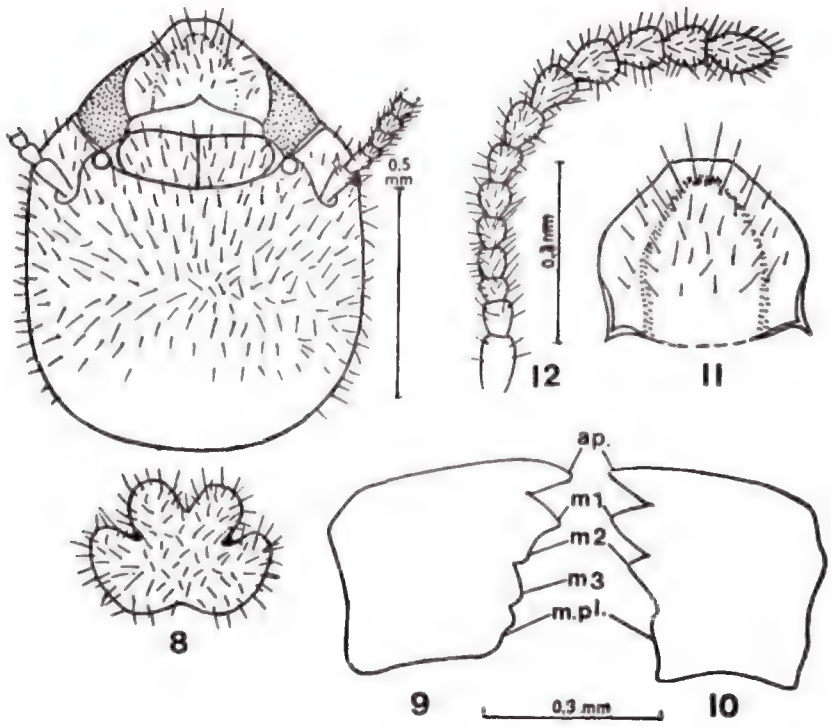
Clypeus; postclypeus not distinctly demarcated from the frons; length less than half its width. Anteclypeus short and translucent. *Mandibles:* Feeble; without any marginal crenulations; outer margins deeply concave basally; convex in the outer third, terminating into weakly incurved apices. *Postmentum*: Well arched; slightly longer than broad.

Thorax: Pronotum strongly saddle shaped; much narrower than head width; anterior margin with a deep notch in the middle; posterior margin small and weakly emarginate. Meso– and metanotum narrower and broader than pronotum respectively; posterior margins straight. *Legs:* Short; tibiae of the fore legs greatly inflated; hind femora long; pilose; tibial spurs 3:2:2 tarsi 4-segmented.

Abdomen: Elongate; hairy: cerci 2–jointed hairy, 0.04 mm long.

Worker major: (Fig. 2, Table 2). Head-capsule, postclypeus and labrum yellowish; mandibles yellow with dark brown toothed margins; antennae, thorax and body pale yellow. Head and body moderately hairy. Total body-length (without antennae) *ca.* 3.50–3.60 mm.

Head: Subsquarish; almost as long as broad; sides substraight; posterior margin broadly rounded. *Fontenelle* : Indistinct. *Eye* and *Ocelli* : absent. Antennae with 13 segments; pilose, pilosity greater distally;



Microtermes bharatpurensis n. sp. (Rathore), Worker major Rajasthan: Bharatpur, Agriculture field *ca.* 5 km NW of Kumher. (8) Head and pronotum in dorsal view; (9) Left mandible in dorsal view; (10) Right mandible; (11) Labrum in dorsal view; (12) Left side antenna enlarged. ap, apical tooth of mandibles; lt, Left mandible; m1 – m3; 1st to 3rd marginal teeth of mandibles; mpl, molar plate; rt, right mandible.

segment 1 longest, cylindrical; 2nd little longer than half of 1, cylindrical, 3–5 short and broad; 3rd shortest; 4 and 5 subequal; 6 to 12 gradually becoming long and pyriform; last (13) ovate and longer than the penultimate one. *Clypeus* : Anteclypeus apilose, anterior margin projected in front in the middle; postclypeus greatly swollen, pilose and divided into right and left halves. *Labrum:* Broader than long; broadest in middle; with several long and short hairs all over the body; anterior margin rounded. *Mandibles:* of typically *Microtermes* - type. Left mandible with an apical and 3 marginal teeth; apical finger like; 1st margical subequal to apical; 2nd short and separated from 1st marginal subequal to apical; 2nd short separated from 1st by a long margin; 3rd marginal small; situated just above the molar plate. Right mandible with an apical and 2 marginal teeth; apical finger-like; 1st marginal subequal to apical but broader at base; 2nd short and close to 1st.

Thorax: Pronotum saddle shaped; much narrower than head-capsule; much broader than long; anterior lobe strongly upturned; anterior margin convex, with a prominent median notch; posterior margin weakly emarginate in middle. Mesonotum narrower than pronotum; sides rounded; posterior margin substraight. Metanotum slighly broader than pronotum; sides rounded; posterior margin substraight.

TABLE 2. Body measurements (in mm) of worker minor and major (4 exs) of *Microtermes bharatpurensis* sp. nov.

	Body parts	Worker major Range	Worker minor Range
1.	Total body length *ca.*	3.50–3.60	2.30–2.38
2.	Head-length with mandibles	1.18–1.20	0.92–0.94
3.	Head-length to lateral base of mandibles	0.90–0.92	0.60
4.	Maximum width of head	0.88–0.90	0.68–0.69
5.	Maximum height of head	0.50–0.52	0.38–0.39
6.	Length of labrum	0.18–0.20	0.15–0.16
7.	Maximum width of labrum	0.32–0.34	0.27–0.28
8.	Number of antennal segments		
	(a) Left antenna	13	13
	(b) Right antenna	13	13
9.	Maximum length of pronotum	0.30	0.25–0.26
10.	Maximum width of pronotum	0.54–0.56	0.42–0.44

Legs: Short and thin; apical tibial spur formula 3:2:2. Tarsi 4-segmented.

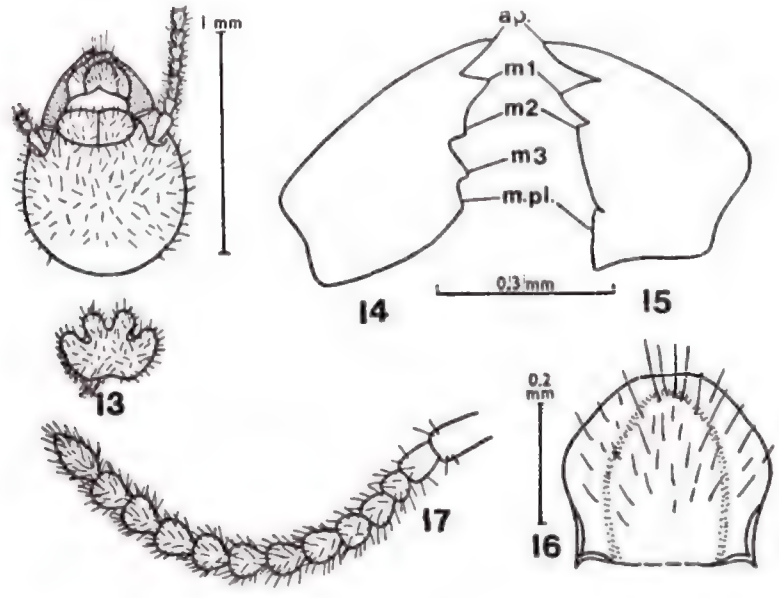
Abdomen: Elongate, hairy. Cerci 2-jointed hairy, 0.06 mm long.

Worker Minor: (Fig. 3; Table 2,) Similar to worker major, except smaller size.

Type - Specimens:

Holotype: One soldier vide "Material", in spirit, in a vial, deposited in the National Zoological Collection, Zoological Survey of India (ZSI), Calcuatta. (ii) **Paratypes** 1 soldier and 4 workers (2 major and 2 minor) in spirit, in a vial, deposited in the National Zoological Collection, Zoological Survey of India (ZSI), Calcutta.

Rest of the material at the Desert Regional Station, Zoological Survey of India, Jodhpur.



Microtermes bharatpurensis n. sp. (Rathore), Worker minor from Rajasthan: Bharatpur, agriculture field *ca.* 5 km NW of Kumher. (13) Head and pronotum in dorsal view; (14) Left mandible dorsal view; (15) Right mandible; (16) Labrum dorsal view; (17) Left side antenna enlarged.
ap, apical tooth of mandibles; lt, left mandible; m1 – m3; 1st to 3rd marginal teeth of mandibles; mpl, molar plate; rt, right mandible.

Type - locality:

INDIA: RAJASTHAN : Kumher, Bharatpur district 27° 15' latitude and 77° 20'E longitude.

Comparison: Soldier : The soldiers of *Microtermes bharatpurensis* is distinct from all other known species of genus *Microtermes* from India by its much smaller size (2.39-2.50 mm *vs* 2.90-4.90 mm), small, weakly hooked mandibles (length 0.45-0.47 *vs* 0.50-0.70 mm), 13 segmented antennae having 3rd segment smallest *vs* 14–16 segmented antennae generally with 3 and 4 subequal.

Worker Major: The worker major of *Microtermes bharatpurensis* is distinct from all other known species from India by its smaller size (3.50-3.60 *vs* 3.50-4.80 mm) and 13 segmented antennae having 3rd smallest *vs* 13–16 with segment. 3 subequal to 4 or 3, 4 and 5 subequal and combined.

ACKNOWLEDGEMENTS

I am thankful to Director, Zoological Survey of India, Calcutta for encouragement in termite work and to Dr. R. C. SHARMA, Scientist-SE, Officer-in-Charge, Zoological Survey of India, Desert Regional Station, Jodhpur for facilities. Finally I am highly obliged to Dr. M. L. ROONWAL, Ex-Director, Zoological Survey of India, for going through the manuscript and useful suggestions.

REFERENCE

CHATTERJEE, P. N. & M. L. THAKUR (1964) Revision of the termite genus *Microtermes* Wasmann (Isoptera: Termitidae : Macrotermitinae) from the Indian Region. — *Indian Forest Records*, **10**(11), 219–260.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 59 to 61

IDENTIFICATION OF INSTARS AND BIOMETRICAL ANALYSIS OF GROWTH DURING POST-EMBRYONY OF *DASYCHIRA HORSFIELDI* STRAND (LYMANTRIIDAE : LEPIDOPTERA) REARED ON APPLE FOLIAGE

P. R. GUPTA[1], J. R. THAKUR & G. S. DOGRA
Department of Entomology & Apiculture,
Dr. Y. S. Parmar University of Horticulture & Forestry, Solan, India 173 230

(*Received* 17 *May* 1988)

***Dasychira horsfieldi* exhibited sexual dimorphism with respect to number of larval instars (6 in the male and 7 in the female) and size of pupae (female being bigger than male). Important identification characters of the larval instars and their growth pattern on basis of regression analysis of size of body and cranium have been described.**

(*Key Words:* instar identification, sexual dimorphism, biometrics, Brooks-Dyar rule)

Dasychira horsfieldi Strand is a polyphagous pest of silvicultural importance with sporadic outbreaks (BEESON, 1941). During early eighties, moderate to heavy attack was observed on apple and walnut nursery plants at Solan, Himachal Pradesh. Preliminary observations on its biology have been recently reported (GUPTA *et al.*, 1987). In the present communication, indentificational characters of larval instars and biometrical analysis of growth during post-embryonic development have been presented to supply more information about the species.

Laboratory rearing was done as described by GUPTA *et al.* (1987). Dimensions of full-fed caterpillars of each instar and pupae (sample size: 50–60 insects) were recorded by vernier calipers. Width of cranium (head capsule) of different instars (except the last one, where vernier calipers were used) was measured under the microscope by ocular piece calibrated with a standard stage micrometer. Data were subjected to regression analysis to determine allometric growth pattern and to facilitate easy identification of the instars.

Neonate larvae before dispersal congregated over the egg mass and devoured the empty shells except the basal glued portion. Instars could be identified on the basis of changes in colour and morphology after each moult. In the first instar larva, head was black, general body light brown, studded with many black verrucae containing white setae and brown bristles; dorsum of third to seventh abdominal segments had black discrete longitudinal streaks; and prolegs furnished with elongate brown plate on their outer aspect. In second instar, head was yellowish and verrucae lost the typical black colour; annular grey-bands appeared at the posterior margin of almost all segments. Third instar caterpillars were conspicuous due to appearance of a black oval patch along the mid dorsal line between first and second abdominal segments. Upon disturbance larva exposed this patch by pressing its head against the substratum and raising pre-pseudopod bearing segments. In the

[1]Regional Fruit Research Station, Shimla, India 171 007.

fourth instar, black oval spot, streaks on abdominal segments and setae-bearing verrucae became more distinct. The body of the fifth instar larva was more hairy and cranium turned brown; median 'tail' or tuft of yellow setae became prominent. In sixth and seventh instars, it was difficult to see the body colour and pattern due to its coverage by long setae and bristles; head capsule was dull yellow to light orange and plates on outer aspect of prolegs were less prominent owing to darkening of prolegs.

Dimensions of larvae and pupae and that of cranium of larvae are given in Table 1. Increase in size of the cranium (Y) in subsequent larval instars showed high positive correlations with increase in body length (X_1) and breadth (X_2) and these are best represented by he equation:

$Y = 0.098\ X_1 + 0.230\ X_2 - 0.280$ ($R = 0.99$). Growth quotient (GQ: size of an instar with respect to that in the preceding one) for body length and breadth varied from instar to instar. But for a particular instar there was not much difference in the rate of growth in length and breadth except the third instar (Table 1) and there was proportionate increase in length and breadth During third instar, the length increased at a rate lower than that for the breadth. Being a sclerotized region, increase in width of the cranium agreed with Brooks-Dyar rule as detailed by DALY (1985). Equation depicting trend in growth of the head capsule (Y) during subsequent instars (X) was:

$\text{Log } Y = 0.673 + 0.162\ X$ ($r = 0.995$; $GQ = 1.45$)

Although body of caterpillars is not sclerotized, increase in length and breadth should not follow Brooks-Dyar rule. But present investigations revealed that when body dimensions of full-fed caterpillars of an instar were recorded before ecdysis,

TABLE 1. Dimensions (in mm) of developmental stages during post-embryony of *D. horsfieldi*.

Stage		Body dimensions		Cranial width
		Length mean ± SE (GQ)	Breadth mean ± SE (GQ)	mean ± SE (GQ)
Larva				
Neonate		2.975±0.093	0.640±0.016	NR
Full fed instar	I	5.965±0.321	1.256±0.047	0.604±0.116
	II	8.940±0.294 (1.5)	1.904±0.064 (1.5)	0.974±0.006 (1.6)
	III	12.438±0.206 (1.4)	2.962±0.017 (1.6)	1.574±0.007 (1.6)
	IV	15.940±0.181 (1.3)	3.911±0.033 (1.3)	2.349±0.012 (1.5)
	V	23.519±0.262 (1.5)	5.742±0.082 (1.5)	3.310±0.067 (1.4)
	VI	30.069±0.385 (1.3)	7.562±0.123 (1.3)	4.352±0.040 (1.3)
	VII	38.604±0.780 (1.3)	9.060±0.188 (1.2)	5.615±0.076 (1.3)
Pupa				
Male		19.494±0.331	7.652±0.163	NR
Female		29.411±0.733	11.300±0.150	NR

Note: Each value is mean of at least 50 samples; GQ = growth quotient; NR = not recorded; SE = standard error of mean.

increase in length (Y_1) and breadth (Y_2) of the body during subsequent instars (X) followed the Brooks-Dyar rule, as per equations given below:

$$\text{Log } Y_1 = 0.671 + 0.134 \text{ X } (r = 0.997; \text{ GQ} = 1.36)$$

$$\text{Log } Y_2 = -0.003 + 0.145 \text{ X } (r = 0.993; \text{ GQ} = 1.40)$$

Sexual dimorphism with respect to size of pupae and number of moults required to enter in the pupal stage was observed. Male moths emerged from pupae of smaller size (18-23 mm long and 6.5–9 mm wide) which required six larval moults to enter into the pupal stage. Females emerged from bigger pupae (26.9–33 mm long and 10–12 mm wide) and for becoming pupa, larva moulted 7 times. Despite occurrence of an additional instar in the female, adult emergence of the male and the female was more or less synchronous. It is possible if the female larva, which is apparently indistinguishable from the male larva until sixth moulting, takes less time to complete the respective instar than the male larva. Much variation found in the duration of larval instars in the third (4-7 days), fourth (4–7), fifth (6–11) and sixth (8–15 instars than in the first and second (5-6 days) and seventh (8-11) instars (GUPTA *et al.*, 1987). provides circumstantial evidence to this. BEESON (1941) observed 6–8 larval moults in *D. horsfieldi* (*D. grotei* Moore) and he could not observe sex related variation in number of moults in this species. However, in no instance 8 larval instars were observed in the present studies.

ACKNOWLEDGEMENT

Authors are grateful to Dr. S. L. GUPTA, Division of Entomology, Indian Agricultural Research Institute, New Delhi, for indentification of the species.

REFERENCES

BEESON, C. F. C. (1941) The Ecology and Control of the Forest Insects of India and Neighbouring Countries. Part I. *The Ecology of Forest Insects* (first reprint, 1961) 767 pp. Government of India.

DALY, H. V. (1985) Insect morphometrics. *A. Rev. Ent.*, **30**, 415–438.

GUPTA, P. R., J. R. THAKUR & J. P. SHARMA (1987) Biology of *Dasychira horsfieldi* Strand (Lymantriidae: Lepidoptera) as pest of apple in Himachal Pradesh, 351–353, *in: Advances in Research on Termperate Fruits* (eds. CHADHA, T. R., V. P. BHUTANI & J. L. KAUL) Dr. Y. S. Parmar University of Horticularure and Forestry, Solan.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 63 to 66

PERFORMANCE SPECIFICATIONS OF AN INTRODUCED PARASITOID, *ALLORHOGAS PYRALOPHAGUS* (MARSH) ON DIFFERENT LABORATORY HOSTS

CHANDISH R. BALLAL & PRADYUMN KUMAR
Biological Control Laboratory - I,
Division of Entomology and Nematology,
Indian Institute of Horticultural Research, Bangalore, India 560 089

(*Received* 31 *March* 1988)

The performance of a Mexican parasitoid, *Allorhogas pyralophagus* (Marsh) (Hymenopera: Braconidae) was studied in the laboratory on five different host insects. The per cent parasitism obtained on three pyralids, *Chilo partellus* (Swinh), *C. infuscatellus* Snell., *C. auricilius* (Dudg.) and a noctuid *Sesamia inferens* (Wlk.) were statistically similar while significant reduction in per cent parasitism was observed on *Corcyra cephalonica* (Staint.) (Lepidoptera : Galleridae). Among the four well preferred hosts, *C. partellus* was observed to be most suitable for rearing *A. pyralophagus*, as developmental time of the parasitoid was minimum and longevity and fecundity were maximum when reared on this host insect.

(*Key words:* *Allorhogas pyralophagus*, exotic parasitoid, host preference)

INTRODUCTION

Allorhogas pyralophagus (Marsh) (Hymenoptera: Braconidae) is an exotic parasitoid (origin : Mexico) which was imported into India from the CIBC stations in West Indies and Pakistan for trials against graminaceous borers. Field releases and recoveries made of this parasitoid in Trinidad, Texas and Sumatra (BENNET et al., 1983) and India (ANON, 1983) indicate the need for improving and increasing the laboratory culture of this parasitoid for further field releases.

BENNETT et al. (1983) have reported that *A. pyralophagus* can develop on the following pyralid borers, i.e., 4 species of *Diatraea*, *Eoruma loftini* (Dyar), *Chilo* spp. and *Scirpophaga nivella* (Wlk.). JAYANTH & NAGARKATTI (1985) have also observed that besides pyralids like *Chilo partellus* (Swinh.), *C. auricilius* (Dudg.), *C. infuscatellus* Snell., *C. sacchariphagus indicus* Kapur, *Acigona steniella* (Hamps.) and *Scirpophaga incertulas* (Wlk.), a noctuid *Sesamia inferens* (Wlk.) was also readily accepted by the exotic parasitoid. But, detailed investigations have not been carried out to find out the performance of *A. pyralophagus* on different laboratory hosts. The following studies were conducted to choose the best laboratory host for mass rearing the above parasitoid.

MATERIALS AND METHODS

A. pyralophagus was reared in the laboratory using the technique developed by JAYANTH & NAGARKATTI (1985). Host preference tests were conducted utilising five host insects - *C. partellus*, *C. infuscatellus*, *C. auricilius*, *S. inferens* and *Corcyra cephalonica* (Staint). *C. infuscatellus* was reared on sugarcane stalks and *C. cephalonica* on crushed jower grains. *C. partellus* was reared on an artificial diet of kabuligram flour base developed by NAGARAJA (personal

Contribution No. 25/88 of the Indian Institute of Horticultural Research, Bangalore–560 089.

communication). Artificial diets formulated by VERMA & AVASTHY (1973) and LINGAPPA (1978) were utilised for rearing *C. auricilius* and *S. inferens* respectively. The parasitoid was reared for a generation on each host and thus conditioned to a particular host before conducting host preference tests.

Glass chimneys (21 × 7 cm) covered with muslin cloth on both sides and provided with cotton swabs soaked in 50% honey, were used as the experimental units. Mature host larvae were inserted into drinking paper straws and exposed for 24 hours to the parasitoid at the rate of 3 larvae per mated female parasitoid (based on preliminary studies). This test was repeated for all the five host insects and the treatments were replicated adequately as per CRD.

The developmental time, per cent parasitism, number of cocoons per larva, sex ratio, longevity and fecundity of the adults obtained were the parameters checked up on each host insect. The data was subjected to statistical analysis.

RESULTS AND DISCUSSION

Table 1 shows that the per cent parasitism obtained on *C. partellus* (37.41), *C. infuscatellus* (39.35), *S. inferens* (38.48) and *C. auricilius* (38.48) (when exposed for 24 h) were all statistically on par showing the equally high preference of *A. pyralophagus* for all the four host insects. But, per cent parasitism was significantly reduced on *C. cephalonica* (17.38), which is in conformity with the observation made by JAYANTH & NAGARKATTI (1985). While in an earlier study (ANON, 1986), *A. pyralophagus* was reported to be unable to multiply on *S. inferens*, our studies showed that the per cent parasitism obtained on the same host insect was statistically similar to that obtained on other host insects tested (except *C. cephalonica*).

Number of cocoons per larva ranged from 4.03 on *C. infuscatellus* to 8.9 on *C. auricilius* (Table 1). However, the differences between the values obtained on different hosts were statistically insignificant.

The mean values of developmental time, per cent females obtained, longevity of adults and progeny production are also given on Table 1. The parasite could develop on *C. partellus* in the shortest time (14.0 days) followed by *C. auricilius* (16.0), *S. inferens* (18.67), *C. infuscatellus* (19.67) and *C. cephalonica* (20.33). More females

TABLE 1. Laboratory performance of *A. pyralophagus* on different host insects.

Host insects	Per cent parasitism	No. of cocs/ larva	Developmental time (in days)	Per cent females	Male longevity (in days)	Female longevity (in days)	Fecundity per female
C. partellus	37.41a	8.43	14.0b	83.1	28.67a	34.0	39.17a
C. infuscatellus	39.35a	4.03	19.67a	78.3	25.83a	26.0	35.5ab
S. inferens	38.48a	6.77	18.67ab	64.5	19.33b	21.0	19.5b
C. auricilius	38.48a	8.9	16.0b	81.7	24.67ab	27.33	25.5ab
C. cephalonica	17.38b	4.83	20.33a	85.7	28.0a	32.33	32.77ab
CD at 5%	16.54	NS	2.82	NS	5.87	NS	19.58

Treatment means followed by the same letter are not statistically different.

than males emerged from the cocoons formed on all five host insects. However, per cent females obtained on different hosts ranged from 64.5 to 85.7, the values being statistically on par.

Male and female parasitoids reared on *C. partellus* lived for a comparatively longer time. While the longevity of females obtained on the different hosts were statistically similar, the longevity of males reared on *S. inferens* was significantly reduced.

Highest progeny production was by the females reared on *C. partellus* (39.17) which was statistically on par with the progeny production by the parasitoids reared on *C. infuscatellus* (35.5), *C. cephalonica* (32.77) and *C. auricilius* (25.5). Significant reduction in progeny production was seen only in the case of parasitoids reared on *S. inferens* (19.5).

From the above observations it is evident that of the five host insects tested, *C. cephalonica* is least suitable for rearing *A. pyralophagus* because of the low per cent parasitism and long developmental time. Considering the per cent parasitism obtained, *C. partellus, C. infuscatellus, C. auricilius* and *S. inferens* were found to be suitable. However, the long developmental time of the parasitoid when reared on *C. infuscatellus* and the significant reduction in the male longevity and progeny production of the female when on *S. inferens* are some problems encountered while using the above two host insects. The per cent parasitism, developmental time and longevity of the parasitoid on *C. auricilius* was statistically on par with that on *C. partellus* indicating that both can be considered as efficient laboratory hosts for rearing *A. pyralophagus*. But, the progeny production by the female parasitoid obtained on *C. auricilius* was conidersably reduced in comparison with that on *C. partellus*. Besides in the course of rearing *C. partellus* and *C. auricilius* in the laboratory on artificial diet, it was observed that disease incidence was more in the latter than in the former by nearly 30%. This is a clear disadvantage of using *C. auricilius* as a laboratory host.

It can be concluded from the above study that *C. partellus* is the best laboratory host for rearing *A. pyralophagus* as good per cent parasitism, short life cycle and maximum longevity and fecundity of the parasitoid were recorded on this host. The ease of rearing this host insect on artificial diet is an added advantage. From the above study, it is also clear that *C. infuscatellus, C, auricilius* and *S. inferens* could be used as alternate laboratory hosts.

ACKNOWLEDGEMENTS

We are grateful to Dr. R. M. PANDEY, Director, Indian Institute of Horticultural Research, Bangalore for the facilities provided and to Dr. F. D. BENNETT, Director Commonwealth Institute of Biological Control for arranging shipment of the parasite. We are also thankful to Dr. H. NAGARAJA, formerly Entomologist, CIBC, Indian Station for providing the formula of the artificial diet for rearing *Chilo partellus*. The technical Assistance provided by Mr. S. HANUMANTHARAYA (T–2) is gratefully acknowledged.

REFERENCES

ANONYMOUS (1983) *Annual Report of All India Co-ordinated Research Project on Biological Control of Crop Pests and Weeds.* I I H R, Bangalore.

ANONYMOUS (1986) *Annual Report of All India Co–ordinated Research Project on Biological Control of Crop Pests and Weeds.* I I H R, Bangalore.

BENNETT, F. D., M. J. W. COCK & C. F. A. DIAZ (1983) *Allorhogas* sp. n. (braconids), a potential biological control agent for graminaceous stem borers from Mexico. *Entomology Newsletter*, Int. Soc. Sug. Tech., **14**, 9–12.

JAYANTH, K. P. &. S. NAGARKATTI (1985) Mass rearing techniques for a Mexican parasite. *Allorhogas* sp. (Hymenoptera: Braconidae) inroduced for trials against graminaceous borers in India. *Entomon*, **10**, 43-46.

LINGAPPA, S. (1978) Development of artificial diet for mass rearing *Sesamia inferens* Walker (Lepidoptera : Noctuidae) and screening for resistance in finger millet germplasm. *Ph. D. Thesis.*, *Univ. Agri. Sci.*, Bangalore, 188 pp.

VARMA, A. & P. N. AVASTHY (1973) An artificial diet for rearing of stalk borer, *Chilo auricilius* Dudg. *Experientia*, **29**, 1161.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 67 to 70

VARIATIONS IN THE INCIDENCE OF PARASITISM OF *CHROMATOMYIA HORTICOLA* (GOUR.) (DIPTERA : AGROMYZIDAE) DURING THE DIFFERENT PARTS OF THE YEAR

ANAND KUMAR[1]
School of Entomology, St. John's College, Agra, India 282002

(*Received* 31 *March* 1988)

The survey carried out during the years 1979-1980, 1980-1981 and 1981-1982 indicate that among pupal parasites *Opius turcicus* (Fischer), *Opius exiguus* (Wesm.) (Braconidae) and *Sphegigaster* sp. (Pteromalidae) are major parasites of *Chromatomyia horticola* (Gour.) (Diptera : Agromyzidae) on *Pisum sativum* and *Brassica campestris*. The parasitism by the pupal parasites *O. turcicus* and *O. exiguus*, shows that in the beginning *O. turcicus* remains the dominant component till January. Thereafter, *O. exiguus* outnumbers the former and remains numerically superior till the crop is harvested. The pupal parasite *Sphegigaster* sp. plays relatively minor role in controlling the pest population.

(*Key words*: agromyzid, *Chromatomyia horticola*, parasitism, *Opius turcicus*, *O. exiguus*, *Sphegigaster* sp.)

INTRODUCTION

During the course of the present investigations, on *Pisum sativum* and *Brassica campestris*, a total of twelve species of Hymenopteran parasites viz., *Opius turcicus* Fischer, *O. exiguus* (Wesm.), *O. phaseoli* (Fischer), *Apanteles* sp. (Braconidae), *Chrysonotomyia formosa* West., *Diglyphus isaea* (Walk.), *Eulophus* sp., *Pediobius* sp., *Tetrastichus* sp. (Eulophidae) and *Sphegigaster* sp., *Halticoptera* sp., *Callitula* sp. (Pteromalidae), were reared from the pupae of *Chromatomyia horticola* (Gour.) (Diptera : Agromyzidae). Of the twelve parasites reared *O. turcicus*, *O. exiguus* and *Sphegigaster* sp. are of greater importance as they constitute the dominant component of the parasite complex, while the rest are insignificant as the parasitization caused by them is almost negligible. In India, the significance of Hymenopterous parasites as natural checks on the *C. horticola* population has not yet been evaluated. Therefore, detailed investigations were carried out on the influence of these parasites on the population of leaf-miner *C. horticola* (KUMAR, 1985, a, b, c, d, e). The present paper deals with variation in the incidence of parasitism of *C. horticola* during the different parts of the year.

MATERIAL AND METHODS

The material for the present study was collected from the *P. sativum* and *B. campestris* growing areas around Agra.

The Hymenopterous parasites were reared from the field collected parasitized pupae of *C. horticola* in the rearing cabinet maintained at 30 ± 2°C, 70% RH to obtain adult parasites.

RESULTS AND DISCUSSION

The surveys carried out during the year 1979–1980, 1980–1981 and 1981–1982 indicate that a high rate of mortality of the leafminer

[1]Present address: Entomology Section, Central Sericultural Research and Training Institute, Srirampuram, Manandavadi Road, Mysore, India 570 008.

on *P. sativum* and *B. campestris* is caused by parasitism.

The results of pupal parasitism for three years at Agra on *P. sativum*, are given in Table 1. With the appearance of pupal parasites the pupal mortality gradually increases as the season advances, and in March more than half the pest population is killed by these parasites. The highest pupal parasitism was observed in the month of March with 58.00% in 1979–1980, 53.33% in 1980–1981 and 56.00% in 1981–1982. HAFEZ *et al.* (1974) reported the parasitism of *Liriomyza congesta* on bean plants caused by *Diglyphus isaea* and *Ophius* sp. which reached upto 75.00% towards the end of the season.

A careful study of the table would show that *O. turcicus* remains the dominant component of the parasite complex upto January. Thereafter, *O. exiguus* outnumbers them and remains numerically superior till the crop is harvested. The highest pupal mortality caused by *O. turcicus* was observed in January with 20.00% in 1979–1980, 22.85% in December, 1980–1981 and 16.66% in 1981–1982. *O. exiguus* appeared for the first time in January in 1979-1980 as compared to 1980–1981 and 1981–1982 where it was observed in December. The pupal parasitism caused by this parasite attains the peak in the second week of March with 32.00% in 1979–1980, 30.00% in 1980–1981 and 36.00% in 1981–1982. *Sphegigaster* sp. plays relatively minor role in controlling the pest population. It appeared in February in 1979–1980, 1980–1981 and 1981–1982. The highest mortality caused by this parasite was observed in March with 10.00% in 1979–1980 and in the month of February with 10.00% in 1980–1981 and 9.29% in 1981–1982. TAKADA & KAMIJO (1979) reported about 4.00%

TABLE 1. Data giving information about pupal parasitism of *Chromatomyia horticola* caused by *Opius turcicus*, *O. exiguus* and *Sphegigaster* sp. on *Pisum sativum*, during the years 1979-1980, 1980-1981 and 1981-1982 at Agra.

Year	Month	No. of pupae	Pupa parasitized by						Total percentage parasitism
			Opius turcicus		*Opius exiguus*		*Sphegigaster* sp.		
			Number	Percentage	Number	Percentage	Number	Percentage	
1979-80	November	—	—	—	—	—	—	—	—
	December	118	20	16.94	—	—	—	—	16.94
	January	150	30	20.00	18	12.00	—	—	32.00
	February	200	24	12.00	52	26.00	16	8.00	46.00
	March	100	16	16.00	32	32.00	10	10.00	58.00
1980-81	November	—	—	—	—	—	—	—	—
	December	140	32	22.85	8	5.71	—	—	28.56
	January	141	30	21.27	19	13.47	—	—	34.74
	February	480	40	8.33	120	25.00	48	10.00	43.33
	March	120	18	15.00	36	30.00	10	8.33	53.33
1981-82	November	15	—	—	—	—	—	—	—
	December	135	21	15.55	4	2.22	—	—	17.77
	January	300	50	16.66	23	7.66	—	—	24.33
	February	355	22	6.19	72	20.28	33	9.29	35.76
	March	100	12	12.00	36	36.00	8	8.00	56.00

pupal mortality in the first generation caused by *Sphegigaster hamugurivora*.

The results obtained during the year 1979–1980, 1980–1981 and 1981–1982 on *B. campestris*, at Agra, fairly correspond with those obtained for *P. sativum*.

The results of pupal parasitism observed on *B. campestris* during the years 1979–1980, 1980–1981 and 1981–1982, at Agra, are given in Table 2. A study of the table would reveal that the highest pupal mortality was caused in the month of March with 56.66% and 52.30% and 50.00% in 1979-1980, 1980-1981 and 1981–1982 respectively. TANDON (1971) reported that Hymenopterous parasites make their appearance at the end of the last week of February on *B. campestris* and parasitize about 97.20% pupae in the second week of April.

It is clear from the above table that *O. turcicus* appeared in December 1979–1980, 1980–1981 and 1981–1982. The maximum parasitization was observed with 20.00% in January in 1979–1980, 16.92% in March in 1980–1981 and 14.00% in January and March in 1981–1982. The parasite *O. exiguus* appeared in January in 1979–1980 and 1981–1982 and December in 1980–1981. It was dominant in February and March till the crop is harvested. The peak parasitism was attained in the second week of March with 33.33%, 26.15% and 30.00% pupal mortality in 1979–1980, 1980–1981 and 1981–1982 respectively.

Sphegigaster sp. appeared in February in 1979–1980 and 1981–1982 and January, 1980–1981. The maximum pupal mortality was observed in the month of February with

TABLE 2. Data showing the percentage of pupal parasitism of *Chromatomyia horticola* caused by *Opius turcicus*, *O. exiguus* and *Sphegigaster* sp. on *Brassica campestris*, during the year 1979-1980, 1980-1981 and 1981-1982 at Agra.

Year	Month	No. of pupae	Pupae parasitized by						Total percentage parasitism
			Opius turcicus		*Opius exiguus*		*Sphegigaster* sp.		
			Number	Percengage	Number	Percentage	Number	Percentage	
1979-80	November	12	—	—	—	—	—	—	—
	December	90	12	13.33	—	—	—	—	13.33
	January	190	38	20.00	10	5.26	—	—	25.26
	February	250	35	14.00	65	26.00	25	10.00	50.06
	March	120	18	15.00	40	33.33	10	8.33	56.66
1980-81	November	—	—	—	—	—	—	—	—
	December	105	12	11.42	3	2.85	—	—	14.27
	January	250	30	12.00	36	14.40	6	2.40	28.80
	February	345	39	11.30	69	20.00	36	10.43	41.73
	March	130	22	16.92	34	26.15	12	9.23	52.30
1981-82	November	14	—	—	—	—	—	—	—
	December	128	12	9.37	—	—	—	—	9.37
	January	300	42	14.00	13	10.00	—	—	24.00
	February	320	30	9.37	76	23.75	26	8.12	41.24
	March	250	21	14.00	45	30.00	9	6.00	50.00

10.00% in 1979–1980, 10.43% in 1980–1981 and 8.12% in 1981–1982.

The results of the surveys carried out on *P. sativum* and *B. campestris* during the year 1979–1980, 1980–1981 and 1981–1982, at Agra clearly indicate that *O. turcicus* is more effective than *O. exiguus* upto the month of January, except on *B. campestris* in 1980–1981 where the latter parasite dominated upto the month of December. Thereafter, *O. exiguus* assumed the dominant role and maintained its superiority by killing greater portion of the pest population till the end of the crop season.

It is also evident from the three years surveys on *B. campestris* and *P. sativum* that amongst the pupal parasites, the braconids *O. turcicus* and *O. exiguus* play a dominant role in parasitizing the pest population while the pteromalid *Sphegigaster* sp. is relatively of minor significance in the parasite-complex.

ACKNOWLEDGEMENTS

I offer my grateful thanks to Dr. SANTOKH SINGH, Head of the Zoology Department, St. John's College, Agra for guidance and encouragement. I am also thankful to Dr. CICY MAMMEN for her help in many ways.

REFERENCES

HAFEZ, M. A. L., EL-KIFF, M. N. DONIA & A.E.A. WAHEB (1974) Studies on parasites of *Liriomyza congesta* (Becker) in Egypt. *Bull. Soc. Ent. Egypte*, **58**, 249–259.

KUMAR, A. (1985a) Estimation of damage caused to *Chromatomyia horticola* population on *Brassica campestris* by Hymenoptera parasites. *Entomon*, **10**, 49–53.

KUMAR, A. (1985b) Incidence of parasitism of *Diglyphus isaea* (Walk.) on *Chromatomyia horticola* (Gour.), a pest of *Pisum sativum* in Northern India. *Entomon*, **10**, 55–58.

KUMAR, A. (1985c) Estimation of damage caused to *Chromatomyia horticola* (Gour.) population on *Pisum sativum* by Hymenoptera parasites, at Agra. *J. Curr. Biosci.*, **2**, 68-73.

KUMAR, A. (1985d) Records and distribution of some new Hymenopterous parasites of *Chromatomyia horticola* (Gour.) (Diptera: Agromyzidae) from India. *J. Curr. Biosci.*, **2**, 79–81.

KUMAR, A. (1985e) Correlation between the rate of increase in the incidence of parasitism of *Chromatomyia horticola* (Gour.) (Diptera : Agromyzidae) with the climatic conditions at Agra. *J. Environ. Res.*, **1**, 17–21.

TAKADA, H. & K. KAMIJO (1979) Parasitic complex of the garden pea leaf-miner, *Phytomyza horticola* Gourea in Japan. *Kontyu*, **47**, 18–37.

TANDON, S. K. (1971) Notes on the Biology of *Phytomyza atricornis* Meigen, a common leaf-miner of cruciferous plants (Agromyzidae : Diptera). *Agra Univ. J. Res. (Sci.)*, **20**, 47–68.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 71 to 73

EFFECT OF FOUR CHITIN SYNTHESIS INHIBITORS ON THE RED COTTON BUG, *DYSDERCUS KOENIGII* FABRICIUS

G. T. GUJAR & K. N. MEHROTRA
Division of Entomology, Indian Agricultural Research Institute, New Delhi, India 110012

(*Received* 31 *March* 1988)

Effect of four chitin synthesis inhibitors, diflubenzuron, penfluron, teflubenzuron and triflumuron, on the last instar nymphs of the red cotton bug, *Dysdercus koenigii* Fabricius was studied. It was observed that of these four chemicals, penfluron was the most effective chitin synthesis inhibitor against *D. koenigii*. LD_{50} values expressed in μg/nymph were found to be diflubenzuron 0.269, penfluron 0.025, teflubenzuron 0.112 and triflumuron 0.359. The results of the present investigations showed that chitin synthesis inhibitors possessed high contact activity against the hemipterous insect species, *D. koenigii*.

(*Key words*: chitin synthesis inhibitors, insect growth regulators, red bug, *Dysdercus koenigii* Fabricius)

INTRODUCTION

The chitin synthesis inhibitors of acylurea type are known to affect synthesis and deposition of chitin in insect integument (MULDER & GIJSWIJT, 1973). They have been found to be highly effective insecticides against defoliators, especially those belonging to Lepidoptera and Coleoptera (RETNAKARAN *et al.*, 1985). They affect insect growth and development at the time of moulting leading to the formation of various morphogenetic deformities in insects (VAN DAALEN *et al.*, 1972). The information on effect of chitin synthesis inhibitors on hemipterous insects is very meagre. The present communication reports the effect of four chitin synthesis inhibitors viz., diflubenzuron, penfluron, teflubenzuron and triflumuron on the moulting of last instar nymphs to the adult stage of the red cotton bug, *Dysdercus koenigii* Fabricius.

MATERIALS AND METHODS

Insects used in the present study were obtained from a laboratory colony of the red cotton bug, *D. koenigii* maintained at 27°C and 70 $\pm$ 20% relative humidity. These were fed on soaked cotton seeds which were replaced daily so as to maintain cleanliness. Under these conditions, developmental period of nymphs was found to be 21 days. The last instar nymphs, 0–24 h old, were topically treated with different concentrations of chitin synthesis inhibitors in 5 μl acetone each. Thus, nymphs were individually treated with different doses of chitin synthesis inhibitors viz., 10, 2, 0.4, 0.08, 0.016, and 0.0032 μg each. Control insects received 5 μl acetone each. The data on mortality and morphogenetic abnormality were recorded until adult emergence. LD_{50} values were calculated on the basis of mortality until adult emergence (FINNEY, 1971).

Diflubenzuron, 1–(4–chlorophenyl – 3–(2, 6–diflurobenzoyl) urea, Penfluron, 1 –(4–trifluromethyl phenyl)–3–(2,6–diflurobenzoyl) urea, were gifts from Dr. A. B. Borkovec, Chief, Insect Reproduction Laboratory (USDA), Maryland, USA; Teflubenzuron, 1–(3, 5–dichloro–2, 4–difluorophenyl) – 3–(2,6–diflurobenzoyl) urea was gift from Dr. P. Becker Celamerck, FRG and Triflumuron, 1–(4–trifluromethoxy-phenyl) - 3-(2- chlorobenzoyl urea was gift from Dr G. Zoebelein, Bayer. AG, FRG. All chemicals used in the present study were of technical grade.

RESULTS AND DISCUSSION

The chitin synthesis inhibitors are known to cause morphogenetic deformities by affecting moulting to next instar or stage. In the present studies, these chitin synthesis inhibitors did not cause acute mortality even at the highest dose of 10 μg. However, their effects were manifested at the time of moulting to adult, that is, 6 days after treatment. Figure 1 shows in detail the morphogenetic effects caused by these chitin synthesis inhibitors in *D. koenigii*. The highest dose of chitin synthesis inhibitor initially delayed moulting by about 1 day followed by high nymphal mortality. At higher doses effect was usually nymphal mortality alongwith dead nymphal-adult intermediates. At lower doses, it was usually abnormal adults. These adults had deformed wings. Similar morphogenetic effects were observed on treatment of nymphs with penfluron in *Dysdercus cingulatus* (REENA *et al.*, 1984).

It was also seen that all four chitin synthesis inhibitors were found to possess varying degree of toxicity through contact action. The cent per cent mortality of nymphs was seen at a dose of 10 μg in diflubenzuron and teflubenzuron, and at 2 μg level in penfluron while triflumuron did not cause 100% nymphal mortality even at 10 μg dose level. Table 1 shows comparative toxicities of chitin systhesis inhibitors against last instar nymphs of *D. koenigii* after subjecting data to log concntration - probit analysis according to FINNEY (1971). The LD_{50} (μg/nymph) values for various chitin synthesis inhibitors were found to be penfluron 0.025; teflubenzuron 0.112; diflubenzuron 0.270 and triflumuron 0.36 on the basis of mean weight of last instar nymph of 19.3 mg (S D 4.86), LD_{50} (μg/g body weight) was found as penfluron 1.27; teflubenzuron 5.78; diflubenzuron 13.94 and triflumuron 25. 88. It is seen that penfluron is the most effective contact chitin synthesis inhibitor. It has been reported that these chitin synthesis inhibitors are less effective against hemipterous and other sucking pests of agricultural crops. The present findings show that chitin synthesis inhibitors especially penfluron was highly effective aginst *D. koenigii* through contact action. Similarly, chitin synthesis inhibitors have been studied and found effective to varying extent; penfluron for *D. cingulatus* (REENA *et al.*, 1984), triflumuron for *Dysdercus intermedius* (HAMMANN & SIRRENBERG, 1980), diflubenzuron for *D. koengii* (PAUL RAO & REDDY, 1982), *Dysdercus similis* (ARUNA KUMARI *et al.*, 1982) and

TABLE 1. Toxicity of four chitin synthesis inhibitors to last instar nymphs of *Dysdercus koenigii* Fabricius.

Chitin synthesis inhibitor	LD_{50} (μg/nymph)	Fiducial limits	het.	Regression equation
Diflubenzuron	0.269	0.175–0.415	0.038	Y = 3.121 x — 2.583
Penfluron	0.025	0.010–0.061	0.178	Y = 1.365 x + 3.102
Teflubenzuron	0.112	0.055–0.226	3.607	Y = 1.260 x + 2.420
Triflumuron	0.359	0.094–1.372	0.372	Y = 1.156 x + 2.044

LD_{50} values are based upon nymphal mortality and other dead morphogenetically deformed insects occurring at the time of moulting to adult stage, that is, 7 days after treatment.

Figure 1. Morphogenetic effects produced by chitin synthesis inhibitors on *Dyscdercus koenigii* (left 1–4) and right: normal adult.

Dysdercus superstitistus (VAN DAALEN *et al.*, 1972). The high toxicity of penfluron in *D. koenigii* was close to that in *D. cingulatus* (REENA *et al.*, 1984). Although all four chitin systhesis inhibitors are basically of benzoyl phenyl urea type, they differ with respect to substitution at benzoyl and phenyl rings with halogens. These substitutions affect their solubility in organic solvents thereby resulting in differences in partition coefficient which may have profound effect on penetration kinetics. Hence, the differences in relative toxicities of these chitin synthesis inhibitors may also be perhaps due to their differential penetration in *D. koenigii*. In conclusion, the present results show high efficacy of chitin synthesis inhibitors aganst hemipterous insect, *D.koenigii*.

ACKNOWLEDGEMENTS

Thanks are due to Dr. S. K. BHATIA, Head, Division of Entomology for providing facilities.

REFERENCES

ARUNA KUMARI, S. S. THAKUR, B. KISHEN RAO & D. RAGHUNATH RAO (1982) The effect of Dimilin as an IGR on the cotton stainer, *Dysdercus similis*. *Proc. Indian Acad. Parasit.*, **3**, 35–39.

VAN DAALEN, J. J., J. MELTZR, R. MULDER & K. WELLINGA (1972) A selective insecticide with a novel mode of action. *Naturwissenschaften*, **59**, 312–313.

FINNEY, D. J. (1971) *Probit Analysis*. 3rd edition, Cambridge University Press, Cambridge, 333 pp.

HAMMANN, I. & W. SIRRENBERG (1980) Laboratory evaluation of SIR 8514, a new chitin synthesis inhibitor of the benzoylated urea class. *Pflanzenschutz Nachrichten Bayer*, **33**, 1 34.

MULDER, R. & M. J. GIJSWIJT (1973) The laboratory evaluation of two promising new insecticides which interfere with cuticle deposition. *Pestic. Sci.*, **4**, 737–745.

PAUL RAO, G. D. J. & G. P. V. REDDY (1982) Effect of dimilin (diflubenzuron) against red cotton bug and rice moth. *The Andhra agric. J.*, **29**, 105–109.

REENA, C., K. SATYANARAYANA & K. SUKUMAR (1984) Ecdysial disruption by penfluron in *Dysdercus cingulatus* (F.). *Int. Pest Control*, **26**, 154–155 & 157.

RETNAKARAN, A., J. GRANETT & T. ENNIS (1985) Insect growth regulators, 529–601, *'in : Comprehensive Insect Physiology, Biochemistry and Pharmacology*, **12** (Ed. by G. A. KURKUT & L. I. GILBERT) Pergaman Press, Oxford.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 75 to 77

A NEW SPECIES AND THE FIRST RECORD OF THE GENUS *PRISCAPALPUS* DE LEON FROM INDIA (TENUIPALPIDAE : ACARI)

G. L. SADANA & RAJINDER SIDHU
Department of Zoology, Punjab Agricultural University, Ludhiana, India 141 004

(*Received* 31 *March* 1988)

A new species of *Priscapalpus* De Leon, namely *P. piarai* sp. nov. has been described and illustrated. The genus is recorded for the first time from India. With the addition of the present record, the total number of species now known for this genus from the world stand at four. A key to the species of this genus is also given.

(*Key words:* *Priscapalpus*, Tenuipalpidae from India)

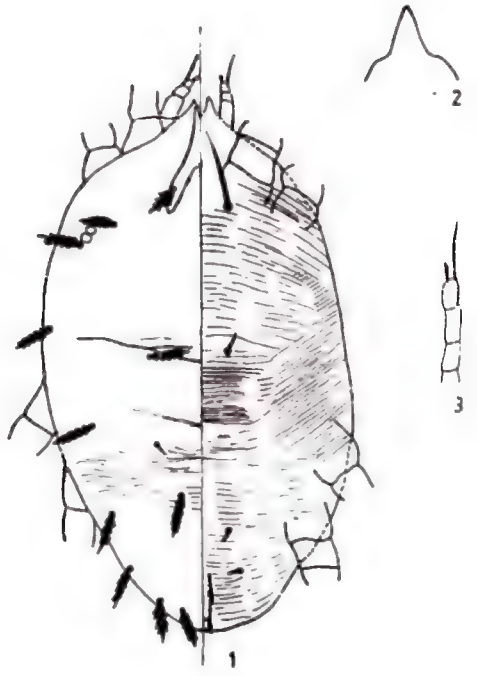
De Leon (1961) erected the genus *Priscapalpus* with *P. macropilis* as type species. He stated that this genus resembled *Brevipalpus* Donnadieu in dorsal chaetotaxy but differed from it in bearing an enlarged ventral plate, a rudimentary genital plate, two segmented palpus and uncinate true claws. He (De Leon, 1965) added another species, *P. cherreti* to this genus which differed from *P. macropilis* in having only two pairs of dorsocentral setae. On these bases, Mitrofanov (1973) described a new genus viz., *Deleoniella* for *P. cherreti*. Meyer (1979) after discovering a new species namely *P. thomissus* and comparing with the known species of the genus did not agree with the erection of *Deleoniella* which is monotypic and stated that the value of fused genitoventral plate as a character for the creation of genus cannot be justified. She, therefore, considered *Deleoniella* as synonym of *Priscapalpus*. Ghai and Maninder (1984) also supported Meyer (1979) in this regard. We also feel that it is not advisable to create closely related monotypic genera keeping in view our present state of knowledge of this family and also when new species are being discovered. We have found a new species of the genus *Priscapalpus* De Leon from India and after comparing it with the known species of this genus, it is redefined as follows:

Palpus with two to four segments. Propodosoma with three pairs of dorsal setae; hysterosoma with a pair of humeral setae, four to five pairs of dorsolateral and two to three pairs of dorsocentral setae; dorsosublateral setae being absent. Genital and ventral plates not clearly defined, incompletely or completely fused. True claws hooked or pad-like.

Priscapalpus piarai sp. nov. (Figs. 1–3)

Female: Body 259* long (with rostrum), 223 long (without rostrum) and 142 wide. Palpus four segmented, terminal segment with a solenidium and a seta. Propodosoma provided with rostrum which reaches upto the base of femur I. Propodosoma bare, without any striae. Propodosomal setae 3 pairs, spatulate and serrate, measuring 12.09, 12.09, and 14.43 from first to third respectively. Humeral setae 1 pair, spatulate and serrate, measuring 13.14. Hysterosoma with a few transverse lines. Dorsocentral

*All measurements are in μm.



Figs. 1-3. *Priscapalpus piarai* sp. nov. 1. Dorsal view (left half), ventral view (right half) of female; 2. Rostral shield of female; 3. Palpus of female.

setae 3 pairs, short, I 9.36 II 3.91 and III 8.38. Dorsolateral setae V pairs, spatulate and serrate, I 13.84, II 13.06, III 14.43, IV 14.23 and V 12.87.

Gnathosoma without any ventral setae. Medio-ventral propodosomal setae 1 pair, 23.47 long. Anterior medioventral metapodosomal setae 1 pair, 6.04 long. Ventral plate not clear, having a pair of setae measuring 4.98. Genital plate area with 1 pair of setae, measuring 4.68. Anal setae 2 pairs, minute. Venter of propodosoma and hysterosoma with faint finger print like striae.

Legs 4 pairs, segments wrinkled, the counts of setae with solenidia (in parentheses) of legs I–IV are: coxae 2—1—1—1, trochanters 0—0—1—1, femora 2—2+1 (spatulate) —2+1 (spatulate) —1, genua 2—2—1—1 tibiae 4(1) — 3—2—2 and tarsi 4+(1)—3+(1)—3+(1)—2+(1). True claws hooked.

Male: Not known

Collection data: Holotype: 1 ♀ on slide No. 67, ex *Psidium guajava*, 17. xii. 1986. Gurdaspur, coll. Piara Lal.

Paratypes: 1 ♀, slide No. 102, same host as for holotype, 23. ii. 1987. Kup Kalan (Sangrur), coll. Ram Das. 1 ♀, slide No. 73, ex *Morus alba*, 18. xii. 1986. Ropar, coll. Piara Lal. 1 ♀, slide No. 93a, ex *Bhambola*, 7. ii. 1987, Dadwindi (Kapurthala); 2♀♀, slide No. 129 and 130 ex *Citrus medica*, 6. iii. 1987, Regional Research Station (Bathinda); 1 ♀, slide No. 138, *Citrus sinensis*, 6. iii. 1987, Bathinda, Coll. Rad Das. 1 ♀, slide No. 125 ex. *Citrus limon*, 7. iii. 1987, Nurmahal (Jullundur), coll. Ajit Singh.

Remarks: The present form shows a slight resemblance with *P. macropilis* De Leon, 1961 in having 3 pairs of dorsocentral setae but differs from it in all other aspects. It also differs widely from *P. thomissus* Meyer 1979 and *P. cherreti* De Leon, 1965, the other, known species of the genus *Priscapalpus*. Hence, the present form is described as new species and is named after its collector.

The genus *Priscapalpus* is being reported for the first time from India.

KEY TO THE SPECIES OF THE GENUS *PRISCAPALPUS*

1. Hysterosoma with 4 pairs of dorsolateal setate; true claws pad like .....*thomissus* Meyer, 1979
— Hysterosoma with 5 pairs of Hysterosomal setae; true claws hooked..... 2
2. Hysterosoma with 2 pairs of dorsocentral setae .....*cherreti* De Leon, 1965
— Hysterosoma with 3 pairs of dorsocentral setae 2
3. Palpus two segmented..... . ... *macropilis* De Leon, 1961
— Palpus four segmented..... .....*piarai* sp. no.

ACKNOWLEDGEMENTS

The authors are thankful to Dr. H. S. TOOR, Professor and Head, Department of Zoology, Punjab Agricultural University, Ludhiana for providing laboratory facilties and I C A R for financing the scheme to carry out taxonomic work on tetranychoid mites. They are also thankful to Dr. (Mrs.) M. DHILLON, Associate Professor Department of Botany for helping in the identification of host plants. The help rendered by Mr. PIARA LAL, Mr. RAM DAS and Mr. AJIT SINGH is gratefully acknowledged.

REFERENCES

DE LEON, D. (1961) A new false spider mite genus from Mexico (Acarina : Tenuipalpidae). *Fla Ent.*, **44** (2), 93 94.

DE LEON, D. (1965) New Tenuipalpidae (false spider mite) from British Guiana, with notes on four described species. *Fla Ent.*, **48** (1) 65–75.

GHAI, S. & M. SHENHMAR (1984) A review of the world fauna of Tenuipalpidae (Acarina : Tetranychoidea). *Oriental Ins.*, **18**, 99–172.

MEYER, M. K. P. (SMITH) (1979) The Tenuipalpidae (Acari) of Africa with keys to the world fauna. *Entomology Mem. Dep. Agric. Tech. Serv. Repub. S. Afr.*, **50**, 1–135.

MITROFANOV, V. I. (1973) Revision of the system of phytophagous mites of the subfamily Brevipalpinae (Trombidiformes, Tenuipalpidae). *Zool. Zh.*, **52** (4), 507–511.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 79 to 80

RESIDUAL TOXICITY OF CERTAIN INSECTICIDES TO LEAF GALL THRIPS (*LIOTHRIPS KARNYI* BAGNALL) ON BLACK PEPPER[1]

S. DEVASAHAYAM
National Research Centre for Spices, Marikunnu, Calicut, Kerala, India 673012

(*Received* 31 *March* 1988)

Nine insecticides were evaluated for their residual toxicity to leaf gall thrips (*Liothrips karnyi* Bangnall) infesting black pepper (*Piper nigrum* L.). Initial toxicity was highest in monocrotophos which caused 90 per cent mortality up to 14 days after treatment. Monocrotophos continued to cause 50 per cent mortality up to 28 days after treatment. Monocrotophos and malathion caused some mortality up to 42 days after treatment. Analysis of PT (Persistence × Toxicity) indices also indicated that residual toxicity was maximum in monocrotophos followed by malathion.

(*Key words*: black pepper, *Piper nigrum* L., leaf gall thrips, *Liothrips karnyi* Bagnall, residual toxicity of insecticides)

INTRODUCTION

Leaf gall thrips (*Liothrips karnyi* Bagnall) are important pests of black pepper (*Piper nigrum* L.) in Kerala especially at higher altitudes. The pest infests the leaves and induces the formation of marginal leaf galls within which they live. The feeding activity of the pest also results in reduction in size, crinkling and malformation of the infested leaves. NAIR & CHRISTUDAS (1976) and VIVEKANANDAN *et al.* (1981) have evaluated a few insecticides against field populations of leaf gall thrips. However, no information is available on the residual toxicity of various insecticides against the pest. The results of such studies conducted with nine insecticides (four systemic and five contact insecticides) are reported here.

MATERIALS AND METHODS

The experiment was conducted at the National Research Centre for Spices, Calicut under green house conditions. Rooted cuttings of black pepper (*var.* Panniyur-1) raised in polythene bags were sprayed with commercial formulations of the test insecticides so as to give a uniform and thorough coverage of the foliage. The insecticides tested included, dimethoate, formothion, monocrotophos, phosphamidon, dichlorvos, endosulfan, methyl parathion, quinalphos (0.05%) each and malathion (0.1%). Forty plants were utilised representing 10 treatments including a control and each treatment was replicated four times. A single leaf was clipped from each plant at 1, 3, 7, 14, 21, 28, 35, 42 and 49 days after treatment and placed in glass vials of 14 × 2.5 cm size, the mouth of which was covered with a muslin cloth. A piece of cotton wool soaked in water was also placed in the vial to prevent dessication of the leaves. Ten adult leaf gall thrips collected from the field were then introduced into each vial and their mortality was recorded after 24 hours. The corrected percentage of mortality under various treatments was calculated using the Abbott's formula (ABBOTT, 1925). The PT (Persistence × Toxicity) values were also calculated based

[1]Contribution No. 81 of National Research Centre for Spices, Calicut 673012.

TABLE 1. Residual toxicity of certain insecticides to gall thrips on black pepper.

Treatments		No. of days for which 90 per cent mortality observed	No. of days for which 50 per cent mortality observed	No. of days for which some mortality observed (P)	Mean mortality (T)	PT index
Dimethoate	0.05%	7	14	35	60.90	2131.50
Formothion	0.05%	7	14	35	58.79	2057.65
Monocrotophos	0.05%	14	28	42	67.93	2853.06
Phosphamidon	0.05%	7	14	28	69.77	1953.56
Dichlorvos	0.05%	0	3	28	37.00	1036.00
Endosulfan	0.05%	7	21	35	70.56	2469.60
Malathion	0.1%	3	21	42	60.14	2525.38
Methyl parathion	0.05%	3	3	35	46.24	1618.40
Quinalpuos	0.05%	3	14	35	52.97	1853.95

on the method suggested by PRADHAN & VENKATARAMAN (1962).

RESULTS AND DISCUSSION

The residual toxicity of various insecticides evaluated in the experiment is presented in Table 1. Initial toxicity was maximum in monocrotophos which caused 90 per cent mortality up to 14 days after treatment followed by formathion, phosphamidon, dimethoate and endosulfan which caused 90 per cent mortality up to 7 days. Monocrotophos continued to cause 50 per cent mortality up to 28 days after treatment; endosulfan and malathion caused 50 per cent mortality upto 21 days. Residual toxicity was maximum in monocrotophos and malathion which caused some mortality (7.9 and 5.3 per cent, respectively) upto 42 days after treatment. The prolonged residual toxicity of monocrotophos and malathion was also evident from their high values of PT (Persistence $\times$ Toxicity), being 2853.06 and 2525.38 respectively. Analysis of PT indices of the test insecticides indicated the following trend : monocrotophos $>$ malathion $>$ endosulfan $>$ dimethoate $>$ formothion $>$ phosphamidon $>$ quinalphos $>$ me thy parathion $>$ dichlorvos.

REFERENCES

ABBOTT, W. S. (1925) A method for computing the effectiveness of an insecticide. *J. econ. Ent.*, **18**. 265 267.

PRADHAN, S. & T. V. VENKATARAMAN (1962) Integration of chemical and biological control of *Chilo zonelius* (Swinh.), the stalk borer of maize and jowar. *Bull. nat. Inst. Sci. India*, **19**. 119–125.

NAIR, M. R. G. K. & S. P. CHRISTUDAS (1976) On the control of *Liothrips karnyi* (Bagnall) pepper leaf gall thrips. *Agric. Res. J. Kerala*, **14**. 173-174.

VIVEKANANDAN, P., A. REGUPATHY, B. HABEEBULLAH, M. BALASUBRAMANIAN & I. IRULAPPAN (1981) Dissipation of insecticides in black pepper applied to control leaf gall thrips *Liothrips karnyi* Bagnall. *Indian Spices*, **18** (2–4), 27–29.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 81 to 84

BIO-ECOLOGY OF *MIMEGRALLA COERULEIFRONS* MACQUART (DIPTERA : MICROPEZIDAE) ASSOCIATED WITH GINGER *ZINGIBER OFFICINALE* ROSC. RHIZOMES[1]

K. M. ABDULLA KOYA
National Research Centre for Spices, Calicut, India 673 012

(*Received* 2 *March* 1988)

The bio-ecology of *Mimegralla coeruleifrons* Macquart (Diptera : Micropezidae) associated with rhizome rot affected ginger rhizomes (*Zingiber officinale* Rose.) was investigated. The egg, larval and pupal periods ranged between 3–4, 9–13 and 8–11 days respectively. The maggots were present only in rhizomes affected by rhizome rot disease. The maggots were also recorded from other species of Zingiberaceae and *Colocasia* sp. Aspects of adult behaviour such as mating and oviposition have been studied. Two hymenopteran parasites were recorded from pupae. A brief description of different stages is also provided.

(*Key words:* ginger, *Zingiber officinale*, rhizome rot disease, rhizome maggots, *Mimegralla coeruleifrons*)

INTRODUCTION

Ginger (*Zingiber officinale* Rosc.) is an important spice crop which is widely grown in Kerala. The crop is attacked by about 20 species of insect pests during different stages of its growth. Among them seven species of dipteran maggots have been reported to cause damage to the rhizomes by various workers. They include *Calobata* sp. (Micropezidae) (FLETCHER, 1914), *Chalcidomyia atricornis* Mall and *Formosina flavipes* Mall (Chloropidae) (MALLOCH, 1927), *Celyphes* sp. (Celyphidae) (NAIR, 1975), *Mimegralla* sp. nr *coeruleifrons* Macquart (Micropezidae), *Eumerus* sp. (Syrphidae) (ANONYMOUS, 1977) and *Eumerous albifrons* Walker (SATHIAMMA, 1979). The maggots are generally seen in rhizomes affected by rhizome rot disease caused by *Pythium* spp., *Fusarium* spp. and *Pseudomonas solanacearum*. Surveys conducted in all major ginger growing areas in Kerala during 1984–1985 indicated that *M.* coeruleifrons was the prominent species occurring in 26.4 per cent of the samples examined (ABDULLA KOYA, Unpublished). Very little information is available on the biology of *M. coeruleifrons*. In view of the association of the maggots with rhizome rot of ginger, detailed studies on the bio-ecology of *M. coeruleifrons* were conducted at National Research Centre for Spices, Calicut and the results are reported here.

MATERIALS AND METHODS

Life history:

Gravid females of *M. coeruleifrons* were collected from the field and released in nylon mesh cages of 1 × 1 × 1 m size containing glass troughs filled with moist soil for egg laying. Ten per cent honey solution soaked in cotton wool was placed in cages for feeding adult flies. The eggs that were laid in soil were collected with a camel hair brush after moistening the soil which facilitated easy collection of the same. The eggs were kept in petriplates for hatching. Crushed ginger rhizome was provided as food material for the emerging larvae. Adequate moisture

[1]Contribution No. 86 of National Research Centre for Spices, Calicut–673 012.

was provided in the petriplates by placing moistened cotton wool. Measurements and descriptions of egg, larva, pupa and adult stages were carried out by observing the same under stereomicroscope and trinocular research microscope. Measurements of mouth hook of the larvae were also taken daily for determining the number of instars. The studies were conducted in the laboratory under a mean temperature of 24.9–30.8°C and relative humidity of 81.9–90.2 per cent. Observations on mating and oviposition behaviour, sex ratio, mode of survival during off-season and alternate food materials were carried out in the field at the NRCS Experimental Farm, Peruvannamuzhi.

RESULTS AND DISCUSSION

Egg:

The eggs were white and spindle shaped; chorion was sculptured with longitudinal lines; the posterior end was .round and the anterior end pointed. The egg hatched in 3–4 days. Eclosion occurred through longitudinal split of the chorion which extended from the anterior end upto 3/4 of the egg. During eclosion head came out first followed by a wriggling movement of the body which helped the remaining portion to come out. The entire process of hatching took 8–10 minutes and occurred generally during the forenoon.

Larva:

Newly hatched larvae were transparent and pale white. There were three instars. Later instar larvae were creamy white. A pair of prominent dark brown spiralces was seen at the posterior end. The duration of 1,2 and 3 instars were 3, 2 and 6 days respectively (range : 3, 2 and 4–8 days, respectively). The maggots fed voraciously on the crushed ginger kept in the petriplates. In the field the maggots were observed to tunnel inside the ginger rhizomes and feed on the internal contents completely leaving the rind portion. Field observations indicated that the maggots were unable to infest healthy rhizomes, but were found to feed on rhizomes affected by rhizome-rot disease.

Pupa:

Pupation occurred within the food material and in the field within the infected rhizomes; however, pupation was found to occur in the soil rarely. The pupae were elongate; nascent pupae were pale brown which soon turned dark brown. The pupal period lasted for 8–11 days.

Adult:

The abdomen, thorax and legs of adult flies were brownish balck and with pale black patches on the wings. Males were smaller than females. Females could be identified by the presence of the elongated last segment of the abdomen which is used as ovipositor. The tarsii of first pair of legs were white and were generally held in front of the insect and were constantly moved about. The measurements of egg, larva, pupa, and adult are presented in Table 1.

Adult behaviour:

Mating and oviposition:

The process of mating involved arousal-mounting – copulation – termination of copulation. A brief courtship occurred leading to arousal of both the sexes. Copulation occurred successively 4–7 times at intervals of 3–6 minutes. The mating pairs remained in copulation for 4–13 minutes each time. Mating occurred throughout the day especially in shaded areas. Mating was observed to be common between 11.00 a.m. and 2.00 p.m. on bright days. They were also observed to fly in the mounted condition, if disturbed. Freshly mated females resisted the attempts of new males by flying away.

TABLE 1. Measurment of egg, larval, pupal and adult stages*.

Stage	Mean	Range	No. observed
Egg (Length × width)	0.776 × 0.171	0.752 — 0.800 × 0.160 — 0.184	20
Larvae (length)			
I instar	2.607	1.224 — 3.980	5
II instar	5.256	6.756 — 9.012	5
III instar	10.224	9.340 — 10.920	5
Mouth hook of larva (length)			
I instar	0.036	0.030 — 0.040	7
II instar	0.077	0.075 — 0.080	7
III instar	0.167	0.140 — 0.185	11
Pupa (Length × Width)	7.783 × 1.616	7.50 — 8.00 × 1.50 — 1.75	15
Adult male (Length × Width)**	11.95 × 1.50	11.00 — 12.50 × 1.50	10
Adult female (Length × Width)	13.65 × 1.75	13.00 — 15.00 × 1.50 — 2.00	10
Adult male — Wing span	16.60	15.50 — 17.50	10
Adult female — Wing span	17.85	17.50 — 19.00	10

* All measurements in mm.
** Width at Throax.

Oviposition occurred soon after mating and eggs were laid singly in the soil up to a depth of 1 cm around the base of the pseudostems near the rhizomes. Females were observed invariably to oviposit near diseased rhizomes. Under laboratory conditions gravid females laid the eggs on the sides of the glass trough and also on cotton wool moistened with honey solution kept for feeding.

Mode of survival during off-season :

The maggots of *M. coeruleifrons* were observed to grow in fallen and decaying banana flowers, rejected bits and roots of ginger heaped in the field during the period from January to May, when the crop is not in the field. The duration of life cycle (35–45 days) was prolonged when the maggots were reared on banana flowers in the laboratory as compared to 20–28 days on ginger. Adults were also observed in the field in moist and shaded areas during this period and exhibited normal activities such as mating, egg laying etc. However, the adult population during this period was considerably low.

Alternate food material :

The maggots of *M. coeruleifrons* were observed in the rhizomes of rot affected turmeric (*Curcuma longa*), wild arrow root, *Colocasia* sp. and wild ginger (*Zingiber* sp.). The maggots have been earlier reported to infest *C. longa*, *C. aromatica* and *C. zeodaria* (ANONYMOUS. 1979). PREMKUMAR et al. (1982) reported that maggots also fed on *C. longa*, *C. aromatica* and *Kaemferia galanga*.

Sex ratio :

Sex ratio of males and females in the field was about 1:1 and there was not much change throughout the year.

Natural enemies :

Two pupal parasites were recorded. They were *Trichopria* sp. (Diapriidae) and *Spalangia gemina* Boucek. (Pteromalidae) ; the latter has been recorded for the first time. Twelve to twenty adults of *Trichopria* were observed to emerge out from a single pupa of *M. coeruleifrons*. Only one adult of *Spalangia gemina* emerged out from a parasitised pupa.

Trichopria species has also been recorded on *Mimegralla* sp. (ANNONYMOUS, 1977). An unidentified species of spider was also observed to feed on newly emerged adults in the field.

ACKNOWLEDGEMENTS

I am grateful to Dr. I. M. WHITE, Dr. A. POLASZEK and Dr. Z. BOUCEK of Commonwealth Institute of Entomology, London for identifying the insect and its natural enemies.

REFERENCES

ANONYMOUS (1977) *Annual Report for* 1976. Central Plantation Crops Research Institute, Kasaragod, India. 283 pp.

ANONYMOUS (1979) *Annul Report for* 1977. Central Plantation Crops Research Institute, Kasaragod, India. 204 pp.

FLETCHER, T. B. (1914) *Some South Indian Insects and other animals of importance considered especially from an economic point of view.* Government press, Madras. 565 pp.

MALLOCH, J. R. (1927) Some Indian Chloropidae (Diptera) of Economic Importance. *Ann. Mag. Nat. Hist.*, **19**, 577 581.

NAIR, M. R. G. K (1975) *Insects and Mites of Crops in India.* Indian Council of Agricultural Research, New Delhi. 404 pp.

PREMKUMAR, T., Y. R. SARMA & S. S. S. GAUTAM (1982) Association of Dipteran Maggots in Rhizome Rot of Ginger, *in: Proceedings of the National Seminar on Ginger and Turmeric*, 8-9 April, 1980, Calicut (Eds. Nair, M. K., Premkumar, T., Ravindran, P. N. and Sarma, Y. R.) Central Plantation Crops Research Institute, Kasaragod, India 250 pp.

SATHIAMMA, B. (1979) Occurrence of maggot pests on ginger. *Bull. Ent.*, **20**, 143–144.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 85 to 89

COURTSHIP AND MATING BEHAVIOUR OF THE UZIFLY *TRICHOLYGA BOMBYCIS* DECK. (DIPTERA : TACHINIDAE)

G. VEERANNA & M. R. NIRMALA
Karnataka State Sericulture Development Institute, Thalaghattapura,
Bangalore, India 560 062

(*Received* 5 *January* 1988)

The courtship and mating behaviour of *Tricholyga bombycis* Beck. were investigated. The female flies mate only once in their life time irrespective of whether males are unmated or already mated. Even after oviposition for different hours also, the gravid females do not accept the males for pairing. The wings and antennae of males and females play an important role in courtship and mating behaviour. The pseudomating of males was also observed in this species. It is evident that the female flies of *T. bombycis* are monoandrous and males are plolygamous.

(*Key words*: *Tricholyga bombycis*, courtship, mating behaviour)

INTRODUCTION

Courtship and mating behaviour include most of the activities performed by insects in sexual behaviour. The factors such as acoustical, mechanical and visual signals are very important in location and attraction of mates. Pheromonal or chemical communication is also widely prevalant in insects. In *Tricholyga bombycis*, the sex-pheromone produced by the virgin female is responsible for attraction of males for mating (KASTURIBAI *et al.*, 1986).

Tricholyga bombycis Beck. is a serious endoparasite of mulberry silkworm, *Bombyx mori* L. in Eastern Asia including Eastern India (GHOSH, 1949) This fly was introduced into totally unaffected and prosperous sericultural tract of South India in 1980 (JOLLY, 1981). Since, then, uzifly menace posed a serious threat to sericulture industry in South India. It is essential to have a thorough knowledge of the biology and behaviour of any pest, prior to the study on its control by various means. Hence, the present investigation was undertaken to reveal the courtship and mating behaviour of *T. bombycis*.

MATERIALS AND METHODS

The flies cultured in the laboratory were used for the study. Soon after emergence, 30 each of male and female flies were separated and maintained in PVC jars (28 cm × 12.5 cm × 10 cm) and were fed on honey and 5% sucrose. Each female was provided with a male fly for mating. The behaviour of both the flies during pre-mating and the time taken for mating were recorded till the death of the flies. Once after mating the mated males were provided with virgin females, and the gravid females were provided with fresh males for mating

The fact that only one mating of the female took place prior to oviposition in her life time made us to take up study in detail of the mating behaviour of female after oviposition in different duration. The gravid females were provided with 25 silkworm larvae daily, for different durations such as 24 h, 48 h, 72 h, 96 h and 120 h for infestation. These females were provided with unmated male for mating.

For determination of the role of antennae and wings of the flies in the courtship and

mating behaviour. the antennae of males and females were removed at the base and were provided with normals of the opposite sex for mating. Similarly, the wings of males and females were removed at the suture and were provided with normals for pairing.

RESULTS AND DISCUSSION

Observations made on courtship behaviour of *T. bombycis* revealed that the female and male flies start vibrating the antennae, lifting of the abdomen and rubbing of the legs against the wings as well as posterior part of the abdomen. The period of courtship ranged from 2-345 min. After courtship, the male fly alights on the dorsal side of the female by clasping her head with his forelegs, her thorax with his middle legs, with his third pair of legs resting on the floor and mates with her (Figs. 1–5). SRIHARAN *et al.* (1971) reported that in *T. bombycis* the mating takes place on the same day of emergence and female flies mate with the males three times in 24 h. Flies of *Exorista lavicepes* start on the third day after emergence (RAHAMAN, 1970). DATTA & MUKHERJEE (1978) observed in the sterilization of male flies of *T. bombycis* with tepa and thiotepa that normal females mated with both treated as well as normal males. On the contrary, THANGAVELU *et al.* (1985) reported that only male flies of *T. bombycis* are polygamous. In the present study, it was observed that the female flies mate only once in their life time irrespective of whether male is unmated or already mated. Even after oviposition for different durations, the gravid females did not accept the males for pairing (Table 1). The mating takes place from 10 h to 3 days after their emergence. Single mating is sufficient to fertilise all the eggs. The duration of mating ranged from 50 to 115 min. The total fecundity recorded in the normal female flies ranged from 62-606 eggs on *B. mori*. The results of distribution of oviposition, oviposition rhythm and parthenogenesis were corroborated with the results of SRIHARAN *et al.* (1971) and of JOLLY (1981).

The antennae of insects are very important in two respects of sexual behaviour. Removal of antennae blocked the activity of male, to recognise the presence of female

TABLE 1. Gravid female flies allowed to oviposit for different durations on silkworm larvae *B. mori*.

S. No.	Number of flies	Day of first pairing	Duration of pairing (in min)	Number of silkworms provided	Duration of exposure (in h)	Number of eggs laid	Day of second pairing	Duration of pairing
1.	5	2	111 ± 7.66	25	24	114 ± 36.38	—	—
2.	5	2	97 ± 8.62	50	48	258.8 ± 70.43	—	—
3.	5	3	104 ± 27.62	75	72	241.8 ± 18.34	—	—
4.	5	3	108 ± 12.18	100	96	379.4 ± 54.16	(only one out of 5 females)	20 min
5.	5	3	104 ± 10.08	125	120	340.4 ± 32.98	—	—

FIG 1

FIG 2

FIG 3

FIG 4

Fig. 1. Uzifly tapping the wings with hind legs. Fig. 2. Female uzifly rubbing the ovipositor with hind legs. Fig. 3. Uzifly rubbing the antennae with fore legs. Fig. 4. Uzifly rubbing the tip of the abdomen.

Fig. 5. Male uzifly mating with female fly.

indicating that antennae have primary receptor for female sex-pheromone by which male is attracted towards female. Secondly, antennae are very important in aiding male orientation towards female and antennae appear to be a component of male sexual behaviour (ASSEM, 1974; COAL, 1970; MATHEWS, 1975). VINSON (1978) reported that the antennae of both sexes of *Cardiochilies nigriceps* are involed in sexual behaviour. The removal of female antennae of *Aphyeus* resulted in sexual isolation (RAO & DE BACK, 1969). The present investigation reveals that out of twenty antennaless males, only six paired with normal females, and of twenty antennaless females, only eight paired with normal males in capativity (Table 2). Results indicated that the antennae of both male and female flies of *T. bombycis* are very important in sexual behaviour.

Wing fanning and fluttering may serve to orient male from short distance to female odour (COLE, 1970), may affect the female receptivity (ASSEM, 1974) and have quieting effect on them (MILLER & TASO, 1974). Wing fluttering is a common component of sexual behaviour among parasitoid Hymonoptera, Diptera and Coleoptera (ASSEM, 1974; COLE, 1970; KITANO, 1975). The present study reveals that of twenty wingless females, seven paired with normal males and of 20 wingless males, four paired with normal females (Table 2). In the light of the above observations, wings of male and female flies are also essential component in sexual behaviour. When the male flies of *T. bombycis* are in group, pseudomating was also observed.

ACKNOWLEDGEMENT

We are grateful to Mr. H. K. SHIVANANDA, Commissioner for Sericulture and Director of Sericulture, I.C Director, K S S D I and Mr. D. MAHADEVAPPA, Joint Director, of Sericulture and Registrar, K S S D I, for facilities provided and their encouragement.

REFERENCES

ASSEM, J. VANDEN (1974) Male courtship patterns and female receptivity signal of Pteromalinae

TABLE 2. Number of flies paired with antennaless female, wingless female, antennaless male, wingless male and normal flies.

S. No.	Details	Day of pairing	Number of flies paired	Number of flies unpaired	Total number of flies	Duration courtship (in minutes)	Duration of pairing (in minutes)
1.	Antennaless female × normal male	1–5	8	12	20	30–225	30–115
2.	Antennaless male × normal female	1–4	6	14	20	35–230	30–85
3.	Wingles female × normal male	1–3	7	13	20	130–235	20–140
4.	Wingless male × normal female	2	4	16	20	15–120	65–120
5.	Normal female × normal male	1–3	19	1	20	2–345	50–115

(Hymenoptera : Pteromalidae) with a consideration of some evolutionary trends, a comment on the taxonomic position of *Pachycrepoideus vindemiae* Netherlands. *J. Zool.*, **24**, 253–278.

COLE, L. C. (1970) Observations on the finding of mates by male *Phacogenes invision* and *Apantelus medicaginis* (Hymenoptera : Ichneumonidae). *Anim. Behav.*, **18**, 184–189.

DATTA, R. K. & P. K. MUKHARJEE (1978) Sterilization of *Tricholyga bombycis*, a parasite of *Bombyx mori* with tepa and thiotepa. *J. econ. Ent.*, **71**(2), 373–376.

GHOSH, C. C. (1949) *Silk Production and Weaving in India*. C S I R Monograph, 61–62.

JOLLY, M. S. (1981) Uzifly : Its identification preservation and control. C S R & T I, Mysore, 1–8.

KASTURI-BAI, A. R., D. MAHADEVAPPA, M. R. NIRMALA & H. K. JYOTHI (1986) Control of uzifly by semio-chemicals. *Curr. Sci.*, **55** (20), 1038–1040.

KITANO, H, (1975) Studies on the courtship behaviour of *Apanteles glomeratus* L. 2. Role of male wings during courtship and the releaser of mounting and copulatory behaviour in males. *Kontyu*, **43**, 513–521.

MATHEWS, R. M. (1975) Courtship in parasitic wasp, 66–82, in: *Evolutionary Strategies of Parasitic Insects and Mites*. (PRICE, P., Ed.), Plenum Press, New York.

MILLER, M. C. & C. H. TASO (1974) Significance of wing vibration in male *Nasania vitripennis* (Hymenoptera : Pteromalidae) during courtship. *Ann. ent. Soc. Amer.*, **67**, 772–774.

RAHAMAN, M. (1970) *Exorista flaviceps*, tachinid parasite of *Pieris rapae* in South America. *J. econ. Ent.*, **63**, 836–841.

RAO, S. V. & P. DE BACK (1969) Experimental hybridization and an interpretation of evolutionary relationships among the species. *Hilgardia*, **39**, 515.

SHRIHARAN, T. P., M. V. SAMSON, S. KRISHNASWAMY & R. K. DATTA (1971) Laboratory investigation of uzifly, *Tricholyga bombycis* Beck., a tachinid parasite of silkworm, *Bombyx mori*. *Indian J. Sericulture*, **10** (1), 14–19.

THANGAVELU, K., A. K. BHAGAWATI & A. K. CHAKRABORTY (1985) Uzifly menace in mugaculture. *Indian Silk*, **14**(3), 7–10.

VINSON, S. B. (1978) Courtship behaviour and source of sexual pheromone from *Cardiochiles nigriceps*. *Ann. ent. Soc. Amer.*, **71** (6), 832–837.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 91 to 94

BIOEFFICACY OF *BACILLUS THURINGIENSIS* BERLINER AGAINST *ACHOEA JANATA* L. AND *BOMBYX MORI* L.

A. D. DESHMUKH & A. D. DESHPANDE
Marathwada Agricultural University, Parbhani (Maharashtra State), India

(*Received* 12 *December* 1987)

The comparative efficacy of four formulations of *Bacillus thuringiensis* Berliner against third instar larvae of *Achoea janata* L and *Bombyx mori* L was studied in the laboraotry, Marathwada Agricultural University, Parbhani. On the baisis of LC_{50} it was observed that endotoxin based *B. thuringiensis* wettable powder (WP) was more toxic to *A. janata* (LC_{50} 0.041) followed by endotoxin based *B. thuringiensis* liquid (LC_{50} 0.044), Biobit WP containing *B. thuringiensis* (*kurstoki*) (LC_{50} 0.099) and Biobit liquid containing *B. thuringiensis* (*Kurstaki*) (LC_{50} 0.111). While in case of *B. mori*, Biobit liquid was more toxic (LC_{50} 0.111), followed by Biobit WP (LC_{50} 0.147), endotoxin based *B. thuringiensis* WP (LC_{50} 0.398) and endotxion based *B. thruringiensis* liquid (LC_{50} 0.481)).

(*Key words*: *Bacillus thuringiensis*, *Achoea janata*, endotoxin)

INTRODUCTION

One of the major constraints of the castor production in India is the heavy damage caused by castor semilooper (*Achoea janata* L) in the early stage of crop growth. Despite several efforts to control the pest with chemicals, it has become inevitable to use pest management practices. Microbial insecticides, because of their specificity and non – toxicity or pathogenicity to non-target animals are ideal biological control agents and have a major role as one of the important components of pest management.

Though *Bacillus thuringiensis* Berliner is proved effective against semilooper, it has a limitation for its use against the pest in the silk growing areas because of its pathogenicity to silkworm. However, the entomopathogenic activity of a variety of *B. thuringiensis* differs in various insects and different varieties or strains also exhibit differential pathogencity in the same host.

Hence studies were undertaken on the comparative efficacy of different formulations of *B. thuringiensis* against castor semilooper (*A. janata*) and silkworm (*Bombyx mori* L) to find out most effective formulation (s) of the product against the pest with a differential (less) pathogenicity to silkworm.

MATERIALS AND METHODS

A healthy laboratory culture of *A. janata* and *B. mori* was maintained on castor leaves and mulberry leaves, respectively. Experiments were conducted with 3rd instar larvae of *A. janata* and *B. mori*. The material used in experimentation was endotoxin based *B. thuringiensis* wettable powder and liquid ontained from M/s Hindustan Lever Ltd., Bombay and Biobit containig *B. thuringiensis* variety (*kurstaki*) wettable powder and liquid obtained from M/s Microbial Resources Limited, Theale Technology Centre, Theale, Berkshire, U S A.

In the bioassay study, with above material, serial dilutions of 1.00, 0.75, 0.50, 0.25, 0.125, 0.062 and 0.031 per cent concen-

trations were prepared with distilled water including Sandovit (0.05%) as a sticker. Discs of 2.5 cm diameter were cut out from castor leaves for *A. janata* and mulberry leaves for *B. mori* and were applied with 50 microlitre /disc of each of the dilution. These treated leaf discs were placed in specimen tube (one disc per tube) and third instar larvae which were previously starved for 2 hours were released (one larva per tube). The speciman tubes were closed with muslin cloth held in position by rubber band. Fresh food was offered at 24 hour interval. Ten larvae were treated for each concentration as well as for untreated control. Such sets of treatments were repeated 2 to 3 times. Mortality data were recorded at an interval of 12 upto 96 h. The data on percentage mortality were subjected to statistical analysis as per FINNEY (1977). Separate experiments were laid out for different formulations ie., wettable powder and liquid as well as for different test insects i. e., *A. janata* and *B. Mori.*

RESULTS AND DISCUSSION

Efficacy of different formulations based on B. thuringiensis *against* A. Janata

Each of different formulations, based on *B. thuringiensis* against third instar larvae of *A. janata* are presented in Table 1.

From the efficacy of these four formulations of *B. thuringiensis,* it was observed that the endotoxin based *B. thuringiensis* wettable powder was better followed by its liquid formulation, Biobit wettable powder containing *B. thuringiensis* variety (*kurstaki*) and Biobit liquid.

DESHPANDE & RAMAKRISHNAN (1982) stated that pre-dissolved endotoxin of variety *kurstaki* was pathogenic to fifth instar larvae of *A. janata.*

TABLE 1. Efficacy of different formulations based on *B. thuringiensis* against third instar larvae of *A. janata.*

S. no.	Concentration of *B. thuringiensis* formulation (percentage)	Corrected percentage mortality of *A. janata* larvae after 96 h.			
		Endotoxin based *B. t.*		Biobit (*B. t. kurstaki*)	
		WP	Liquid	WP	Liquid
1	0.031	44.44	11.11	40.00	22.22
2	0.062	55.55	55.55	40.00	33.33
3	0.125	77.77	66.66	50.00	55.55
4	0.250	77.77	77.77	60.00	77.77
5	0.500	88.00	88.88	80.00	77.77
6	0.750	88.88	100.00	90.00	88.88
7	1.000	1.00	100.00	100.00	100.00
8	Control	0.00	0.00	0.00	0.00
	LC_{50} value	0.041	0.044	0.099	0.111

BAI *et al.* (1984) also reported three preparations of delta endotoxin to be toxic to the third instar larvae of *Spodoptera littoralis* Boisd.

CREIGHTON & MCFADDEN (1975) found 'Dipel' (*kurstaki*) WP as more effective than flowable in reducing pest population of *Trichoplusia ni, Pieris brassicae* and *Plutella xylostella* on cabbage.

Efficacy of different formulations based on B. thuringiensis *against* B. mori:

Effect of different formulations, based on *B. thuringiensis* against third instar larvae of *B. mori* are presented in Table 2.

From the efficacy of these four formulations of *B. thuringiensis* against third-instar larvae of *B. mori,* it was observed that Biobit liquid containing *B. thuringiensis* variety (*kurstaki*) was more toxic followed by Biobit wettable powder, endotoxin based *B. thuringiensis* wettable powder and liquid formulation.

LI & CHEN (1981) stated that square crystals of endotoxin exhibited highest toxicity to *B. mori.*

GALOWALIA *et al.* (1973) reported crystalline endotoxin of varieties *entomocidus, sotto, alesti, galleriae* and *aizwai* to be more toxic and variety *tolworthi* and *thuringiensis* to be the least toxic to *B. mori.*

MANCHEV (1980) stated that 0.003 per cent 'Dipel' caused 77.3, 66.2, 38.0 and 13.8 per cent mortality in first, second, third and fourth instar larvae of silk worm after varying number of days.

Based on the percentage mortality and ultimate LC_{50} values, endotoxin based *B. thuringiensis* WP may be considered better against castor semilooper *A. janata.* While Biobit liquid containing *B. thuringiensis* (*kurstaki*) was more toxic to *B. mori* it may be judiciously used in the pest control programme in the silk producing areas.

TABLE 2. Efficacy of different formulations based on *B. thuringiensis* against third instar larvae of *B. mori*

S. no.	Concentration of *B. thringiensis* formulation (percentage)	Corrected percentage mortality of *B. mori* larvae after 96 h.			
		Endotoxin based *B. t.*		Biobit (*B. t. kurstaki*)	
		WP	Liquid	WP	Liquid
1	0.031	00.00	0.00	30.00	30.00
2	0.062	00.00	0.000	40.00	40.00
3	0.125	20.00	11.11	40.00	50.00
4	0.250	30.00	22.22	50.00	60.00
5	0.500	60.00	55.55	80.00	70.00
6	0.750	70.00	66.66	80.00	80.00
7	1.000	80.00	77.77	90.00	90.00
8	Control	00.00	00.00	00.00	00.00
	LC_{50} value	0.398	0.481	0.147	0.111

REFERENCES

Bai, C., Venhaecke & D. Degheele (1984) Cytopathology of *Spodoptera littoralis* Boisd midgut epithelium following treatment with delta endotoxin of *Bacillus thuringienis* Berliner. *J. Mededelingen van de facultetis Landbouwwetenschappen Rijksuniversity Gent.*, **49** (39), 875–884.

Creighton, C. S. & T. L. Mc Fadden (1975) Cabbage caterpillar: efficacy of chlordimeform and *Bacillus thuringiensis* in spray mixture and comparative efficacy of several chemical and *B. thuringiensis* formulations. *J. econ. Ent.*, **68**(1), 57–60.

Deshpande, A. D. & N. Ramakrishnan (1982) Pathogenicity of certain serotypes of *Bacillus thuringiensis* Berliner against *Achaea janata* L. *Entomon*, **7**(2), 239–245.

Finney, D.J. (1977) *Probit Analysis.* Cambridge University Press, London, New York, Melbourne.

Galowalia, M. M. S., N. H. E. Gidson & J. Wolf (1973) The comparative potencies of the crystalline endotoxin of eight varieties of *Bacillus thuringiensis* to larvae of *Pieris brassicae* L. *J. Inevertebr. Pathol.*, **21** (3), 301–308.

Li, R. & T. Chen (1981) The toxicity and morphology of the crystal from several strains of *Bacillus thuringiensis*. *Acta Microbiologica Sinica*, 21 (3), 311–317.

Manchev, M. (1980) Induction of spontaneous nuclear polyhedrosis in the silkworm. *Fastitelna Zashchitra.*, **28**(2), 13–14.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 95 to 98

FURTHER RECORDS OF A NEW AND ONE KNOWN SPECIES OF *DROSOPHILA* FROM ARUNACHAL PRADESH, INDIA

K. K. GUPTA & J. P. GUPTA
Genetics Laboratory, Department of Zoology, Banaras
Hindu University, Varanasi, India 221 007

(*Received* 31 *March* 1988)

The present communication deals with the description of a new species, *D.* (*Scaptodrosophila*) *fringefera*, and also gives a new distribution record of one more known species, *D.* (*Drosophila*) *siamana* Hihara and Lin from India.

(*Key words:* new *Drosophila*, Arunachal Pradesh)

During last few years the results of our surveying studies in northeast region of the Indian subcontinent have indicated that the family Drosophilidae is fairly distributed in this region (Singh and Gupta, 1977; Gupta and Singh, 1979; Dwivedi and Gupta, 1979, 1980; Dwivedi et al., 1979; Singh and Gupta, 1981; Gupta and Kumar, 1986; Kumar and Gupta, in press). However, some of the states in this region still await exploration. This paper deals with the description of a new species, *D. fringefera* and also gives a new distribution record of one more known species, *D. siamana* Hihara and Lin from India.

Genus *Drosophila* Fallen

Drosophila Fallen, 1823, Geomyzides Sueciae 2:4. Type species; *Musca funebris* Fabricius; Sweden.

Subgenus *Scaptodrosophila* Duda.

Scaptodrosophila Duda, 1923, Ann. Mus. Nat. Hung. 20:37. Type species: *Scaptodrosophila scaptomyzoidea;* New Guinea.

Drosophila fringefera sp. nov.

Body length : 3.5 mm (♂); 3.64 mm (♀).

Head, ♂ and ♀ : Arista with 3 sparsely placed dorsal and 1 ventral branches in addition to the small terminal fork. Antennae with second segment pale brown; third segment orange brown. Frons including ocellar triangle brown. Orbitals in ratio of 7:3:9, anterior reclinate orbital equidistantly placed between the other two. Second oral bristle not differentiated. Palpi yellowish brown, with 1 apical and 2–3 marginal setae. carina yellow, high and broadened below. Face and cheek brown, greatest width of check one–seventh greatest diameter of eye. Clypeus pale brown. Eyes dark red.

Thorax: Acrostichal hairs regular, in eight rows above dorsocentrals, prescutellars not clearly distinguishable from acrostichal hairs. Anterior scutellars convergent; posterior scutellars crossing each other. Anterior dorsocentral 3/4 length of posterior dorsocentral; distance between anterior and posterior dorsocentral 1/3 of the distance between two anterior dorsocentrals. Mesonotum and scutellum brown. Humerals two, equal. Propleural bristles absent. Thoracic pleura yellowish brown. Sternoindex 0.7.

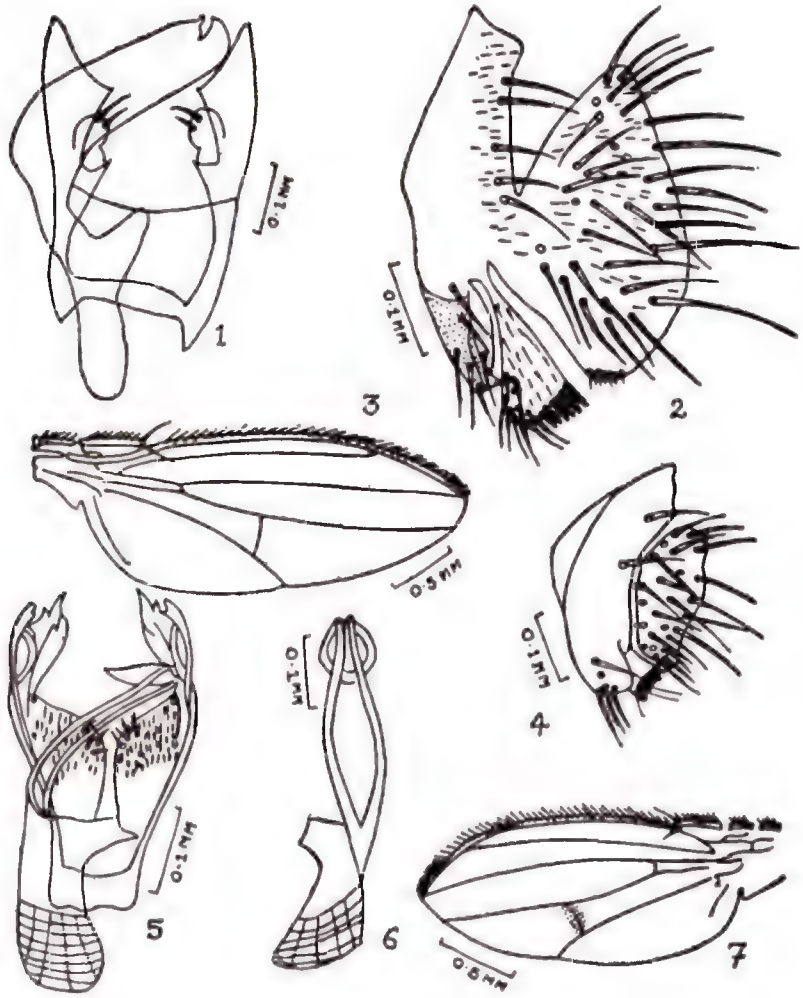
Legs: Coxae and proximal portion of femora light brown, remaining segments of all legs little darker. Preapicals on all three tibiae; apicals on first and second tibiae.

Abdomen : tergites pale brown, with broad, dark brown bands.

Wings (Fig. 3) : Clear. Two equal bristles at the apex of first costal section. C_3 fringe large.

C-index	4V-index	4C-index	5X-index
2.85	1.66	0.81	1.09

Periphallic organs (Fig. 2) : Epandrium dark brown, elongate pubescent, upper portion with 5 bristles, lower portion with 7 bristles. Surstylus large, broadened distally, with 6 large black teeth arranged in a straight row on its upper half, and with 12 large setae ventrally. Cerci large, pubescent, fused with epandrium, and with



Figs. 1–3. *Drosophila* (*Scaptodrosophila*) *fringephera* sp. nov. 1. Phallic organs; 2. Periphallic organs; 3. Male wings.

Figs. 4–7. *Drosophila siamana*. 4. Periphallic organs; 5. Phallic organs; 6. Adeagus; 7. Male wing.

35 large bristles, lower tip with 8–7 small setae.

Phallic organs (Fig. 1): Aedeagus yellowish brown, large, bilobed at basal half. Anterior gonapophyses oval, each with two sensilla. Ventral fragma quadrate.

Holotype: ♂, INDIA: ARUNACHAL PRADESH, Tai, West Siang Dist. November, 1983 (Coll. Gupta and Gupta).

Paratypes: 1 ♂, 1 ♀, same locality and collector as holotype. Deposited in the "*Drosophila* Collection" of the Department of Zoology, Banaras Hindu University, Varanasi, India and Department of Biology, Tokyo Metropolitan University, Tokyo, Japan.

Relationships and comments: This species has been placed in the subgenus *Scaptodrosophila* of the genus *Drosophila* wherein it somewhat resembles the members of the *inornata* group in showing reduced arista and in not having propleural and prescutellar bristles, but distinctly differs from them in having large third costal fringe as well as in the details of male genital structures.

Drosophila (Drosophila) siamana Hihara and Lin

Drosophila siamana Hihara and Lin, 1984. Bull. Inst. Zool. Academia Sinica 23: 205–209.

Head ♀ and ♂ : General features as described by Hihara and Lin (1984).

Wings (Fig. 7): Clear, posterior cross vein mildly fuscous.

C-index	4V-index	4C-index	5X-index
4.0	1.2	1.9	1.6

Periphallic organs (Fig. 4) : Epandrium yellowish brown, having uniform width throughout, incised at the insertion of surstylus, upper portion with 2 bristles, lower portion with 5–6 bristles. Surstylus small, triangular, with 8 small black teeth arranged in a concaved row on outer margin and several fine setate below. Cerci elongate, separated from epandrium, with about 26 bristles.

Phallic organs (Figs. 5 and 6): Aedeagus yellowish brown, bifid and with a membranous structure apically, bilobed at basal half. Anterior gonapophyses large, each with four sensilla. Hypandrium without submedian spines. Ventral fragma quadrate, longer than broad.

Specimens examined: 60 ♂♂, Tai, Arunachal Pradesh, Sept., 1983; 10 ♂♂, Medziphema, Nagaland, August, 1987.

ACKNOWLEDGEMENTS

The authors are grateful to Dr. T. OKADA, Professor Emeritus, Tokyo Metropolitan University, Tokyo, Japan for confirming the identifications and to the U. G. C. for financial assistance.

REFERENCES

DWIVEDI, Y. N. & J. P. GUPTA (1979) Three new Drosophilidae (Diptera: Drosophilidae) from Northeast India. *Entomon*, **4** (2), 183–187.

DWIVEDI, Y. N. & J. P. GUPTA (1980) Records of two known and one new species of *Drosophila* (Drosophilidae: Diptera) from India. *Proc. Ind. Acad. Sci.* (*Anim. Sci*), **89**, 85—89.

DWIVEDI, Y. N., B. K. SINGH & J. P. GUPTA (1979) Further addition to the Indian fauna of Drosophilidae. *Oriental Ins.*, **13** (1–2), 61—74.

GUPTA, J. P. & B. K. SINGH (1979) Two new species of *Drosophila* (Diptera: *Drosophilidae*) from Shillong, Meghalaya. *Entomon*, **4**, 167—172.

GUPTA, J. P. & A. KUMAR (1986) Two new and two unrecorded species of *Drosophila* Fallen from Arunachal Pradesh, India. *Senckenbergiana Biol.*, **67**, 43—49.

HIHARA, F. & F. J. LIN (1984) A new species of *Drosophila hypocausta* subgroup of species from Malaysia and Thailand (Diptera: Drosophilidae: Drosophila). *Bull. Inst. Zool. Academia Sinica.*, **23**, 205—209.

KUMAR, A. & J. P. GUPTA (1988) Additions to the Drosophilid fauna of northeast India. *Anal. Soc. Ent. France* (in press).

SINGH, B. K. & J. P. GUPTA (1977) Two new and two unrecorded species of the genus *Drosophila* Fallen (Dipter: Drosophilidae) from Shillong, Meghalaya, India. *Proc. Zool. Soc.* (*Anim. Sci.*), **30**, 31—38.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 99 to 100

INSECT FEEDING DETERRENT FROM *ECHINOPS ECHINATUS* AGAINST *SPILOSOMA OBLIQUA* WALKER*

PRABIR KUMAR CHAUDHURI & ARUN KUMAR TRIPATHI
Central Institute of Medicinal and Aromatic Plants
Ram Sagar Misra Nagar, P. B. No. 1, Lucknow, India 226016

(*Received* 4 *August* 1987)

The hexane extract of *Echinops echinatus* having strong antifeedant activity against *Spilosoma obliqua* Walker yielded on biodirected isolation three triterpenoids and the active constituents, ethyl palmitate which showed 97.21 per cent protection at 2000 ppm.

(*Key words:* *Echinops echinatus*, Compositae, triterpenoids, ethyl palmitate, antifeedant activity, *Spilosoma obliqua* Walker)

In nature, plants' defensive systems against most insects are attributed to the presence of unpalatable substances (CHADHA, 1986; KUBO & NAKANISHI, 1979; REED & JACOBSON, 1983; VERMA *et al.*, 1986; LWANDE *et al.*, 1983; CHANG & NAKANISHI, 1983). The present authors, during their screening of plants for antifeedant activity against *Spilosoma obliqua* Walker (TRIPATHI & RIZVI, 1985), found strong antifeedant property in the hexane extract of *Echinops echinatus* for the larvae. The biodirected isolation of the hexane extract of this plant led to the characterization of the active constituent as ethyl palmitate which showed 2.79 per cent feeding against *Spilosoma obliqua* Walker at 2000 ppm.

The test insect was reared in laboratory on castor leaves at 27°C±1°C temperature. Freshly moulted 4th instar larvae were kept under starvation for 6 h before conducting the experiment. The crude ethanolic extract was tested by leaf dip method (TRIPATHI & RIZVI, 1985) and fractions were tested by leaf disc method (KUBO & NAKANISHI, 1979).

Extraction: The aerial parts of *E. echinatus* (1 kg) was extracted exhaustively in cold with 75% ethanol (7 lit × 9) and the crude concentrate (100g, E1) was fractionated into n-hexane (40g, E2), chloroform (20g, E3) and n-butanol (20g, E4) parts.

The n-hexane extract (E2) having strong antifeedant activity (Table 1) was chromatographed over silica gel using solvents and solvent mixtures of increasing polarities viz., hexane (I), hexane: ethyl acetate (9:1, II), hexane: ethyl acetate (4:1, III), hexane: ethyl acetate(7:3, IV), hexane: ethyl acetate (3:1,V) hexane: ethyl acetate (1:1, VI), hexane: ethyl acetate (2:3, VII), hexane: ethyl acetate (3:7, VIII), hexane: ethyl acetate (1:4,IX), hexane: ethyl acetate (1:9, X), ethyl acetate (XI) and ethyl acetate: methylalcohol (9: 1, XII). All the fractions were tested at 5000 ppm. The details of antifeedant data are depicted in Table 1. The eluent II afforded a viscous mass which showed 100 per cent protection over control. Further purification of the viscous mass through CC and preparative TLC afforded three triterpenoids viz., lupeol, lupeol acetate, β-amyrin acetate, and a viscous compound (A),

*CIMAP Communication No. 62.

TABLE 1. The antifeedant activity of the fractions and compounds.

Samples	ppm	Percent eaten* after 48 hrs
E1	20,000	9.78
E2	10,000	12.31
E3	10,000	53.77
E4	10,000	48.05
Fractions		
I	5,000	54.21
II	5,000	0.00
III	5,000	6.35
IV	5,000	17.46
V	5,000	25.32
VI	5,000	69.01
VII	5,000	55.72
VIII	5,000	60.37
IX	5,000	60.37
X	5,000	71.42
XI	5,000	67.33
XII	5,000	30.92
Compounds		
Lupeol	2,000	65.41
Lupeol acetate	2,000	71.37
β-Amyrin acetate	2,000	57.40
Ethyl palmitate	2,000	2.79

*Percentage eaten was calculated by formula:

$$\text{Percentage eaten} = \frac{\%\text{ consumed treated} \times 100}{\%\text{consumed (treated + untreated)}}$$

Which gives a total of 50 percent when treated and untreated discs were consumed in equal amounts. The lower the percentage the more active the antifeedant.

identified as ethyl palmitate. The structures of the triterpenoids were determined by their spectral data and direct comparison with the authentic samples (mmp and co-TLC). Compound A on alkaline hydrolysis afforded palmitic acid (M^+256, co-TLC, mmp) and the mass spectral fragmentation of compound A at m/z 284 (M^+), 225, 241, 227, 217, 199, 185, 171, 157, 143, 129, 115, 101 and 88 (base peak) (RHYHEGE & STRENHAGEN, 1963) confirmed its structure as ethyl palmitate (A). All the four compounds were tested at different range of concentrations and the effective concentration was found to be 2000 ppm. The triterpenoids were found to have no significant feeding deterency whereas compound A showed strong antifeedant activity (2.79 per cent feeding) at 2000 ppm.

ACKNOWLEDGEMENTS

The authors are grateful to the Director, CIMAP, Lucknow for constant encouragement during this work.

REFERENCES

CHANDHA, M. S. (1986) Trends in the application of natural products in plant protection. *Proc. Indian Natnl Sci. Acad. B*, **52** (1), 25.

CHANG, C. C. & K. NAKANISHI (1983) Specionin, an iridoid insect antifeedant from *Catalpa speciosus*. *J. Chem. Soc. Chemical Comm.*, **11**, 605.

KUBO, I. & K. NAKANISHI (1979) Some terpenoid insect antifeedants from tropical plants, *in: Advance in Pesticide Science* (Edited by GEISSBUHLER, H., G. T. BROOKES & P. C. KEARHEY) p. 285, IUPAC, Pesticide Chemistry, Pergamon Press, Oxford.

LWANDE, W., T. GEBREYSUS, A. CHAPYA, C. MACFOY, A. HASNALI & M. OKECH (1983) 9-Acridone insect antifeedant alkaloids from *Techtea tricocoarpa* bark. *Insect Sci. Applic.*, **4**, 393.

REED, D. K. & M. JACOBSON (1983) Evaluation of aromatic tetrahydropyranyl ethers as feeding deterrents for the striped cucumber beetle *Acalymma cittatum* F. *Experientia*, **39**, 378.

RYHAE, R. & E. STRENHAGEN (1963) Mass spectrometry of organic ions (Edited by McLafferty, F. W.) 440 p.

TRIPATHI, A. K. & S. M. A. RIZVI (1985) Antifeedant activity of indigenous plants against *Diacrisia obliqua* Walker. *Curr. Sci.*, **54**, 630.

VERMA, G. S., V. RAMAKRISHNAN, N. B. MULCHANDANI & M. S. CHANDHA (1986) Insect feeding deterrents from the medicinal plant, *Tylophora asthmatica*. *Ent. exp. Applicata*, **40**, 99.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 101 to 106

SCOPE OF PARASITES IN BOLLWORM CONTROL

T. SURULIVELU
Central Institute for Cotton Research
Regional Station, Coimbatore, India 641 003

(*Received* 2 *October* 1987)

Through inundative releases of *Chelonus blackburni* Cameron (Hym. Braconidae) and *Bracon kirkpatricki* (Wilkinson) (Hym. Braconidae) recovery of 11.5 and 8.4 per cent was obtained respectively from the larvae of *Earias vittella* Fab. and *Pectinophora gossypiella* Saunders. The release of the parasite, *C. blackburni* brought down the infestation of *E. vittella* considerably in the shed fruiting bodies, squares and flowers. In the laboratory, three day old parasites exhibited a greater efficiency in parasitizing the eggs of *E. vittella*, as compared with one, two and four day old parasites and one day old eggs were more readily acceptable for parasitization than two day eggs of *E. vittella*. The parasite emergence was greater at 11:1 ratio of host-parasite (*E. vittella* and *C. blackburni*) while the parasitism was greater at 9:1. The incidence of the parasite, *Apanteles angaleti* Mueseback (Hym., Braconidae) on *P. gossypiella* was at a greater level in February, which declined considerably in the subsequent months upto May, although the host build up showed a significant increase.

(*Key words: Chelonus blackburni, Bracon kirkpatricki, Apanteles angaleti,* effect on cotton bollworms: *Earias vittella, Pectinophora gossypiella*)

INTRODUCTION

The cotton ecosystem in India is endowed with a rich complex of natural enemies, most of which were listed by KHAN & RAO (1960) but none of these could give satisfactory control of the pests. Introduction of effective natural enemies against three or four of the major pests such as bollworms, white flies and leafhoppers may reduce the need for chemical applications and help to augment natural control of the less important pests. National centre for Bilogical Control (NCBC) of the Indian Institute for Horticultural Research (IIHR), Bangalore, has been supplying the nucleus cultures of exotic parasites of bollworms, particularly *Chelonus blackburni* Cameron, *Bracon kirkpatricki* (Wilkinson) (Hym., Braconidae) and *Trichogramma brassiliensis* Ashmead (Hym. Trichogrammatidae). Reported here are, the studies made on several aspects of the exotic parasites, *C. blackburni* and *B. krikpatricki* in Coimbatore viz., field release and recovery, impact of the parasites on the infestation of bollworms and, the influence of host density (*Earias vittella* Fab.) (Lep., Noctuidae) and age of the parasite, *C. blackburni* on parasitisation and subsequent development. The seasonal incidence of *Pectinophora gossypiella* Saunders (Lep., Gelechiidae) and its important larval parasite, *Apanteles angaleti* Muesebeck (Hym. Braconidae) is also reported.

MATERIALS AND METHODS

Nucleus cultures of exotic parasites, *C. blackburni* and *B. kirkpatricki* were obtained from the National Centre for Biological control, I I H R, Bangalore and mass-bred in the laboratory on their alternate host, *Corcyra cephalonica* Staint (Lep., Galleriidae) following the methods described by BRYAN *et al.* (1973). A total of 10,300 adults of the parasite *C. blackburni* was inundatively released at weekly

intervals at the rate of 5000 parasites per ha per release in an isolated block of the Regional Station Farm (New Area), Central Institute for Cotton Research, Coimbatore, during the peak squaring and fruiting period (October to December, 1980). In the same field, a total of 1260 adults of *B. kirkpatricki* (comprising 1:1 ratio of male and female) were released at different intervals for the control of pink bollworm in the flowers during the same period.

The parasite, *C. blackburni* was released twice at the rate of 5000 per ha during the peak squaring period and the reduction of bollworm infestation (*E. vittella*) was assessed from 50 randomly selected plants, 24 hours before and four weeks after the release of the parasite.

Laboratory studies were made to find out the optimum density of the host, *E. vittella* and the optimum age of the parasite, *C. blackburni* for obtaining the maximum efficiency in the control of bollworm. The host culture was maintained in 'Bhendi' (*Abelmoschus esculentus* Linn.) fruits in the laboratory and the parasite was confined for 24 hours to parasitise the eggs of the host.

The seasonal activity of pink bollworm *P. gossypiella* and its parasite, *A. angaleti* was assessed from 250 randomly selected bolls and 150 g of damaged seed cotton respectively. The Commonwealth Institute of Biological Control (CIBC) has introduced the cultures of *B. kirkpartricki* (origin: Africa) and *C. blackburni* (origin: Hawaii) to the Agricultural Universities and Research Institutes of India in the late seventies (SUDHA NAGARKATTI & SANKARAN, 1978). *C. blackburni* is thelytokous and egg-larval parasite lof bollworms while *B. kirkpatricki* and *A. angaleti* are arrhenotokous, ecto-and endo-laraval parasites of pink bollworm respectively.

RESULTS

The larvae (52 numbers) *E. vittella* were collected from the parasite released field and six parasites (11.5%) could be recovered from the sample (Table 1). The larvae of *P. gossypiella* found in the blooms (83 numbers) were brought to the laboratory and seven larvae (8.4%) were found to be parasitized by *B. kirkpatricki*.

The impact of *C. blackburni* release on the infestation of *E. vittella* is shown in Fig. 1. The infestation due to *E. vittella* was brought down from 61.7, 4.0 and 1.0 to 34.1, 2.6 and 0.7 per cent respectively in the shed fruiting bodies, squares and flowers (Fig. 1).

The influence of host density (*E. vittella*) on the efficiency of parasitization by *C. blackburni* is furnished in the Table 2. The results

TABLE 1. Field release and recovery of parasites.

Name of the parasite	Total no. released	No. of host larvae collected	Parasites emerged	Recovery %
Chelonus blackburni	10,300	52[b]	6	11.5
Bracon kirkpatricki	1,260[a]	83[c]	7[d]	8.4

Note: a – Parasites released at a sex ratio of 1 : 1;
b – lavrae of *E. vittella;*
c – larvae of *P. gossypiella* collected from blooms;
d – larvae of *P. gossypiella* parasitized.

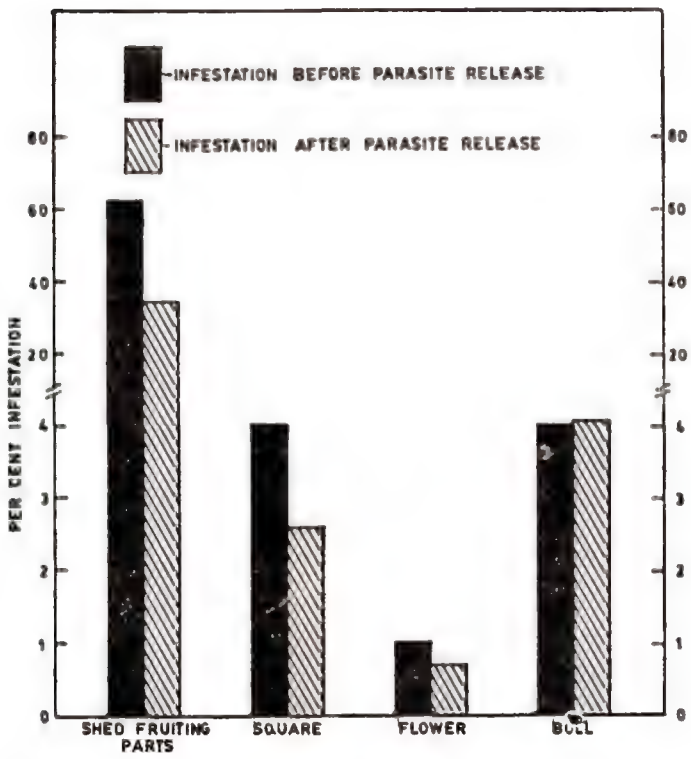


Fig. 1. Impact of *Chelonus blackburni* on the incidence of *Earias vittella*.

TABLE 2. Influence of host density (*Earias vittella*) on parasitization by *Chelonus blackburni*.

Host-parasite ratio	No. of host eggs exposed	*Parasitized host (egg-larva) developing into pupa	Parasite emergence %
3 : 1	30	10.0	6.7
5 : 1	50	12.0	4.p
7 : 1	70	11.4	5.7
9 : 1	90	20.0	5.6
11 : 1	110	8.2	7.3
13 : 1	130	7.4	2.6
15 : 1	150	3.8	2.0

* The larva (*E. vittella*) containing the developing parasite inside its body develops into a reduced size (1/3rd size) pupa as compared to the normal one.

revealed that per cent parasitism was more in host-parasite density of 9:1 while parasite emergence was more in the density of 11:1.

The influence of age of the host, *E. vittella* and the parasite, *C. blackburni* on parasitization and subsequent development of the parasite is presented in Table 3. The results revealed that one day old host eggs were more readily acceptable for parasitization as compared with two day old ones. Number of adults of the parasite emerged was also comparatively more from one day old eggs of the host. Three day old parasites exhibited a greater efficiency in parasitizing the host eggs, as compared with one, two and four day old parasites.

Seasonal incidence of *P. gossypiella* and its parasite, *A. angaleti*: During the year 1980, the pink bollworm infestation in green bolls was assessed in the ORP (Operational Research Project) village, Rudhriampalayam and it was found (Fig. 2) that the infestation was at a moderate level and more or less equal in the months of February (29.5%) and March (29.7%) as against 40.7 per cent in April and 52.7 per cent in May. The larval population of *P. gossypiella* was found to be 11.7, 16.9, 26.5 and 29.9 per 100 bolls respectively in the months of February, March, April and May and the emergence of the predominant larval parasite, *A. angaleti* from 150 g of damaged seed cotton during the same period was 13.5, 6.3, 3.2 and 3.5 respectively. The parasite incidence was greater in February while it declines considerably in the subsequent months up to May, although the host build up showed a significant increase (Fig. 2).

DISCUSSION

Field recovery of *C. blackburni* from *E. vittella* was first observed by THONTADARYA & JAI RAO (1977). Subsequently, Rao Deo *et al.* (1978), SARKATE & RAO DEO (1980) and SWAMIAPPAN & BALASUBRAMINIAN (1980) obtained a recovery of 6.0, 4.8 and 4.5 per cent respectively. RAO DEO *et al.* (1978) also reported 11.1 per cent field recovery of the same parasite from *P. gossypiella* while SWAMIAPPAN & BALASUBRAMANIAN (1980) obtained as high as 59.6 per cent parasitism in the laboratory on *Earias* eggs. In the present study, a greater recovery of 11.5 per cent was obtained from the field collected larvae of *E. vittella* on cotton. This may be due to the inundative releases at shorter intervals (weekly).

TABLE 3. Influence of age of the host *Earias vittella* and parasite *Chelonus balckburni* on parasitization and development.

Age of the parasite in days	Age of the host : 1 day old		Age of the host : 2 days old	
	parasitized pupae %	parasite emegence %	Parasitized pupa %	Parasite emergence %
1	7.6	2.9	0.6	0.6
1	8.0	4.0	6.0	1.6
3	10.7	6.3	8.2	3.1
4	3.4	1.5	5.6	1.4
Mean	7.4	3.7	5.1	1.7

Note: Host-parasite ratio exposed for parasitization was 10:1 respectively.

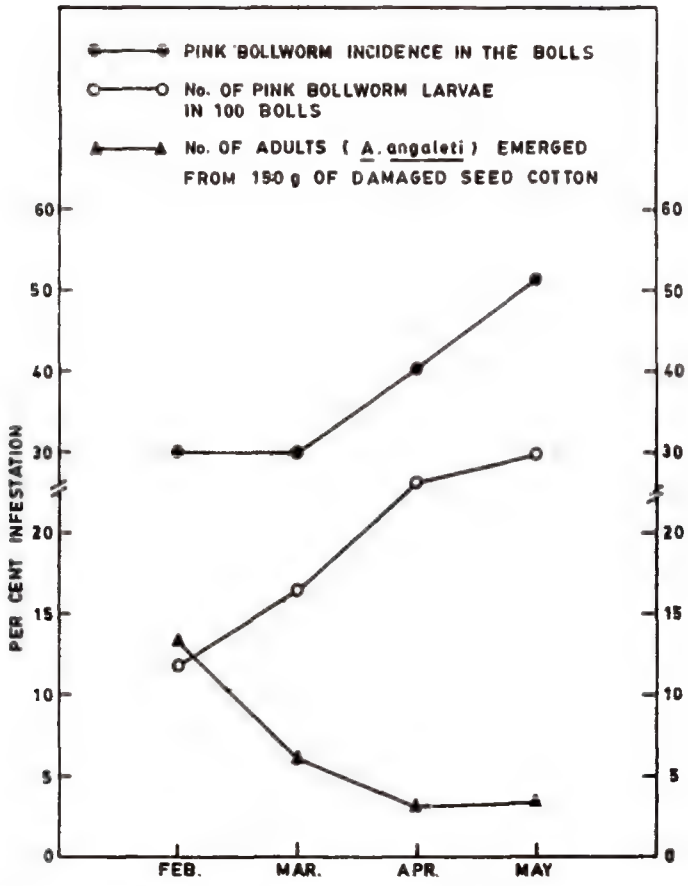


Fig. 2. Seasonal incidence of *Pectinophora gossypiella* and its pararsite *Apanteles angaleti*.

PAWAR *et al.* (1980) first observed 2–10 per cent field parasitism of pink bollworm (*P. gossipiella*) by the exotic parasite, *B. kirkpatricki*. Subsequently, PAWAR & PRASAD (1983) released large numbers of this parasite (6,600) and obtained a recovery ranging from 2.0 to 10.0 per cent from different cotton growing areas of Haryana State. They observed parasitism on the larvae found in the bolls. But in the present study, parasitism (8.4 per cent) was observed on the larvae found in the blooms. The greater level of parasitism observed in this study may be due to easy accessibility of parasite to the larvae found in the blooms as compared to those found inside the bolls.

In the literature, very little evidence is availabe to show the reduction of bollworm infestation by the release of parasites. With an egg parasite, *Trichogramma chilonis* Ishii., CHERIAN & MARGHABANDHU (1943) have shown the reduction of bollworm infestation in the treated field (parasite released field) than in the others. In the present study, the infestation of 61.7, 4.0 and 1.0 per cent was brought down to 34.1, 2.6 and 0.7 per cent respectively in the shed fruiting bodies, squares and flowers. Since the parasite *C. blackburni* effected a good amount of parasitism on the eggs, consequently, the larval infestation was reduced considerably in the shed fruiting bodies and squares.

However, for reasons unknown the boll infestation could not be brought down.

The present study has shown that one day old eggs of *E. vittella* were more readily acceptable for parasitization and resulted in greater number of adult emergence (*C. blackburni*) as compared with two day old eggs of the same host. Three day old adults of his parasite showed a greater efficiency in parasitizing the host eggs, *E. vittella* as compared with 1, 2 and 4 days old adults of the same parasite.

The present study has shown that the pink bollworm infestation was more or less equal (29.5 to 29.7%) during the months of February and March, while it substantially increased to 40.7 per cent in April and 52.7 per cent in May. The larval population in the months of April and May also showed an increase of 126.4 and 155.5 pr cent than that of the population seen in February. The parasite emergence from damaged seed cotton in the corresponding period (Feb. to May) brought out an inverse relationship between the host build up (*P. gossypiella*) and its parasite (*A. angaleti*) development (Fig. 2). In addition to other biotic and abiotic factors the reduction of parasite build up is one of the possible reasons for the greater level of infestation by pink bollworm during April and May.

ACKNOWLEDGEMENTS

The author is thankful to Dr. V. T. SUNDARAMURTHY, Scientist S-3 (Entomology) for the technical help and to Dr. A. K. BASU, Project Co-ordinator and Head, CICR Regional Station, Coimbatore for constant encouragement and facilities extended to the study.

REFERENCES

BRYAN, D. E., R.E. FYE, C. G. JACKSON & R. PATANA (1973) Releases of *Bracon kirkpatricki*(Wilkinson) and *Chelonus blackburni* Cameron for pink bollworm control in Arizona. *Production Res. Rep. U. S. Dept. Agric.*, No. 150, 22 pp.

CHERIAN, M. C. & V. MARGABANDHU (1943) Preliminary trials with *Trichogramma* parasites for the control of the cotton bollworms. *Madras agric. J.*, **31** (4), 107–111.

KHAN, Q. & V. P. RAO (1960) Insect and mite pests, *in: Cotton in India - a Monograph.* Indian Central Cotton Committee, Bombay.

PAWAR, A. D., J. PRASAD & MEERA GUPTA (1980) Biological control of cotton pink bollworm, *Pectinophora gossypiella* Saunders. *Andhra agric. J.*, **27** (1& 2), 33–54

PAWAR, A. D. & J. PRASAD (1983) Field recovery of *Bracon kirkpatricki* (Wilkinson) from the cotton pink bollworm *Pectinophora gossypiella* Saunders in Haryana (India). *Indian J. Ent.*, **45** (2), 195–197

RAO DEO, A. K., M. B. SARKATE & S. N. KULKARNI (1978) Integrated approach for the control of cotton pests in Maharashtra State. *Proc. Seminar on Integrated Pest Management System for Cotton. CICR, Nagapur. Tech. Bull. No.* **4**, 1—10

SARKATE, M. B. & A. K. RAO DEO (1980) Preliminary studies on cotton bolloworms with exotic parasites. *Andhra agric. J.*, **27** (1 & 2), 30–32.

SUDHA NAGARKATTI & T. SANKARAN (1978) The future of integrated control of cotton pests in India. CICR, Nagpur, *Tech. Bull.*, No. 4, 43—52.

SWAMIAPPAN, M. & M. BALASUBRAMANIAN (1980) Studies on mass multiplication and potentiality of *Chelonus blackburni* Cameron, a braconid parasite of cotton bollworms. *Entomon*, **5** (1), 73—75.

THONTADARYA, T. S. & K. JAIRAO (1977) Field recovery of *Chelonus blackburni* Cameron from the cotton spotted bollworm, *Earias vittella* Fab. *Curr. Sci.*, **46** (10), 687

Entomon 1989 Vol. 14 No. 1 & 2 pp. 107 to 108

A NEW SPECIES OF *TERMINALICHUS* ANWARULLAH AND KHAN FROM INDIA (TENUIPALPIDAE: ACARI)

G. L. SADANA & RAJINDER SIDHU (MISS)
Department of Zoology, Punjab Agricultural University
Ludhiana, India 141 004

(*Received* 31 *March* 1988)

A new species of *Terminalichus* Anwarullah and Khan (1973), namely *T. dehlonensis* has been described from India. With the addition of present record, the total number of species of *Terminalichus* now known from the world stand at five. A key to the species of the genus is also given.

(*Key words:* *Terminalichus*, Tenuipalpidae from India)

The genus *Terminalichus* Anwarullah and Khan (1973) was errected with *T. karachiensis* as the type species. This genus was separated from other genera of the family Tenuipalpidae in not having dorsocentral, dorsosublateral and posterior medioventral setae and in possessing ventral plate with a pair of setae in between coxae III and IV. After studying the four known species and the present new record, this genus is characterized as under:-

Rostral shield bifurcated, palpus three segmented, propodosoma with three pairs of dorsal setae; hysterosoma with one pair of humeral, four pairs of dorsolateral, one pair or without dorsocentral setae, the dorsosublateral setae being absent. Ventrogenital plate distinct, longer than broad and possessing a pair of ventral and two pairs of genital setae; anal plate with two pairs of anal setae. Dorsums and venter devoid of striae but with irregular broken lines laterally.

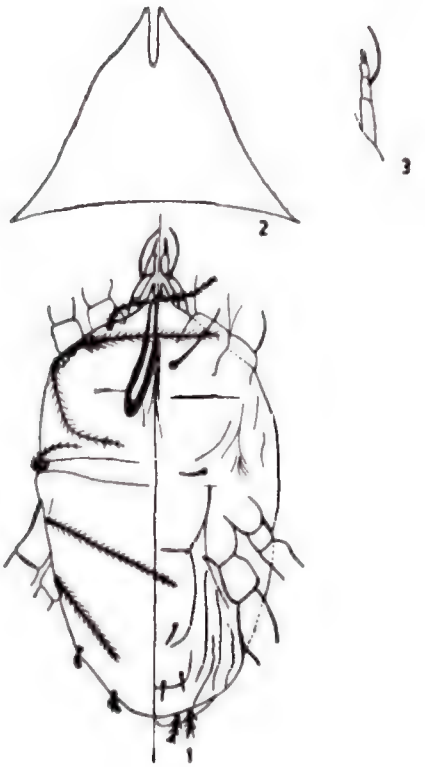
Terminalichus dehlonensis sp. nov. (Figs. 1-3)

Female body 234* long (with rostrum), and 105 wide, palpus 3 segmented, second segment with a long, simple seta, terminal segment with a sensory rod. The propodosoma provided with a bifurcated rostrum extending to end of femur-I. Propodosoma bare, devoid of any striae. Propodosomal setae 3 pairs, all very long and serrate, the sequence of their length in decreasing order being II, I, III. Humeral setae 1 pair serrate and long. Hysterosoma without striae. Dorsocentral setae absent. Dorsolateral setae 4 pairs, serrate, the sequence of their length in decreasing order being I, II, III, IV; setae I and II long and whip-like.

Venter of propodosoma bare, however, with a few oblique striations in the posterior lateral corner. Ventral propodosomal setae I pair, long and filiform. Hysterosoma bare, but with a few longitudinal striations on either side of genito-anal plates. Anterior medioventral metapodosomal setae 1 pair, short and simple. Ventrogenital plate longer than broad, ventral plate setae 1 pair, long, filiform and not crossing the bases of genital setae; genital plate setae 2 pairs, simple and short, anal plate setae 2 pairs equal in length and serrate.

Legs 4 pairs, segments wrinkled, setae on legs I-IV. Coxae 2-2-1-1, trochanters 1-1-1+1(pectinate) -1, Femora 2+1 (pectinate)-1+2 (pectinate) -1+1 (pectinate) -1+1 (pectinate), Genua 1+1 (pectinate)

*All measurements are in μm, unless otherwise stated.



Figures 1–3. *Terminalichus dehlonensis* sp. nov. Fig. 1. Dorsal view (left half), ventral view (right half) of female; Fig. 2. Rostral shield of female; Fig. 3. Palpus of female.

–1+1 (pectinate) –0–0, Tibiae 4–4–2–2, + Tarsus 3–3–3–2+1 (pectinate). Tarsus 1, II and III each with one sensory peg.

Male : Not known.

Collection data. **Holotype**: 1♀ marked on a slide No. 56 ex *Psidium guajava* (Myrtaceae), 17. xii. 1986. (Dehlon Ludhiana), Coll. Rajinder.

Paratype: 1♀ slide no. 57 same host as for Holotype, 17. xii. 1986. Gurdaspur, Coll. Piara Lal.

Remarks: The present form differs clearly from the other four known species of the genus *Terminalichus* i. e., *T. karachiensis* Anwarullah and Khan, 1978; *T. delhiensis* Maninder and Ghai 1978 and *T. psidi* Mohanasundaram, 1983. Therefore, it is described as new species and is named after the locality from which it is collected.

KEY TO THE SPECIES OF THE GENUS *TERMINALICHUS*

1. Anterior pair of dorsocentral setae present ..... *Penajiensis* Maninder and Ghai, 1978
   Dorsocentral setae absent 2
2. First pair of dorsal propodosomal setae shorter than third pair ..... *delhiensis* Maninder and Ghai, 1978
   First pair of dorsal propodosomal setae equal the length of third pair 3
3. Second dorsal propodosomal state not longer than propodosoma ..... *karachiensis* Anwarullah and Khan, 1973
   Second dorsal propodosomal setae longer than propodosoma 4
4. Dorsolateral satae I and II of unequal length... ..... *dehlonensis* sp. nov.
   Dorsolateral satae I and II of equal length..... ..... *psidi* Mohonasundaram, 1983

ACKNOWLEDGEMENT

The authors are thankful to Dr. H.S. Toor, Professor and Head, Department of Zoology, Punjab Agricultural University, Ludhiana for providing the necessary laboratory facilities.

REFERENCES

ANWARULLAH, M. & A. B. KHAN (1973) *Terminalichus karachiensis* n. g., n. sp., a new mite from Pakistan (Acarina : Tenuipalpidae). *Port Acta Biol.*, Ser. B., 12 (1–4), 5—10.

MANINDER & SWARAJ GHAI (1978) Two new species and a new record of the genus *Terminalichus* Anwarullah and Khan from India (Acarina Tenuipalpidae). *Indian J. Ent.*, **40** (2), 217–220.

MOHANASUNDARAM, M. (1983) A new species of *Terminalichus* Anwarullah and Khan from South India (Tenuipalpidae: Acari). *Entomon*, **8** (3), 221—223.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 109 to 115

TWO NEW INDIAN SPECIES OF *PHYTOSCIARA* FREY (SCIARIDAE: DIPTERA)

S. ALAM*, P. K. CHAUDHURI & S. K. DASGUPTA
Department of Zoology, University of Burdwan, Burdwan, India 713 104

(*Received* 2 *October* 1988)

Two new species *Phytosciara* (*Dolichosciara*) *insignituberosa* and *Phytosciara* (*Prosciara*) *bituberosa* are described form India.

(*Key words :* two new Indian *Phyrtosciara*)

The sciarid gnats are generally looked upon as "problem children" of Diptera for their small size and apparent superficial homogeneity. These flies often called dark winged fungus gnats usually prevail around the fungus and other decaying plants and animals. Although these insects are fairly abundant only 38 species were previously described from India and those too mostly belong to the genus *Sciara* (Steffan, 1972a). This paper describes two Indian species of *Phytosciara* Frey (1942) which was so far been recorded only in one species, *flavipes* (Meigen) from the Orient.

Morphology and terminology used here follow Steffan (1972b; 1984) and Alam et al. (1987). The measurements are in millimeter (mm) with the number before parentheses denoting the average value while those within indicating the minimum-maximum suffixed by "n" being the number of specimen encountered.

1. Phytosciara (Dolichosciara) insignituberosa, n. sp. (Figs. 1–11)

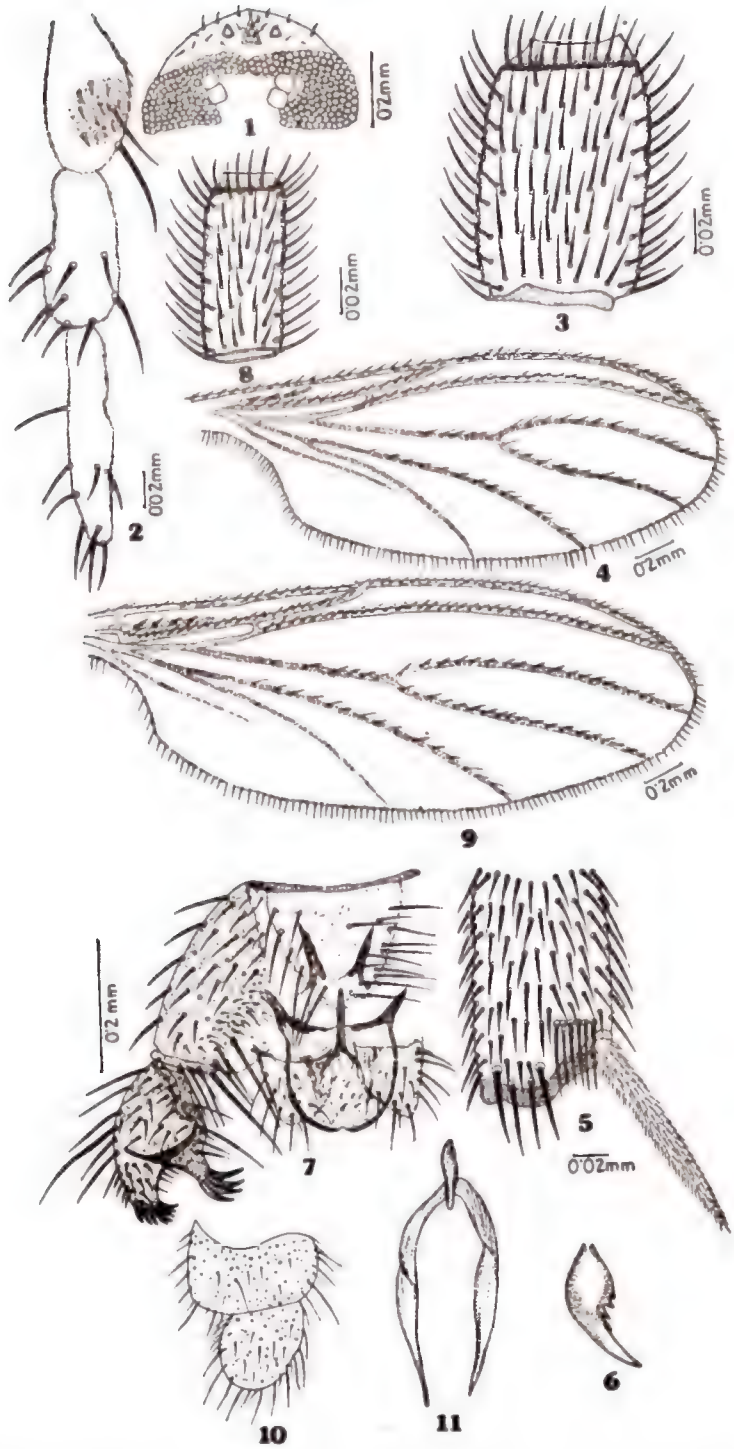
Male:

Head: Dark brown, ovoid, and 0.43 (0.4–0.5, n=8) long. Interfacetal hairs abundant extending 2 × height of facet beyond outer curvature of facets. Eye bridge (Fig. 1) joined constricted at junction and facetal rows. Median ocellus with 3 strong bristles separated from eye bridge by about 1/3 with of ocellus. Anterior vertex pale, 0.27 × length of head with a few weak scattered setae, posterior vertex dark with many strong setae. Prefrons with 3 enlarged ventral and 16–18 weak scattered setae. Clypeus with 1 anterior seta. Labrum narrow, apex blunt, 1/6 length of head. Proboscis 2 × length of labrum. Labellum well developed, width of labellar lobes little greater than the length of proboscis.

Palpus: (Fig. 2) : Light brown with grayish tint, 3-segmented; pp. 34. 0:25.9: 36.6; segment 1 slightly swollen medially with numerous dorsal hyaline sensillae, 1/2 with 2 setae; segment 2 slightly swollen at distal 1/2, about 2/3 length of segment 1, with 1 longer and 8 moderate subequal setae; segment 3 slender, slightly longer but less than 1/2 of the width of segment 1, distal 2/3 with 9 setae.

Antenna: Dark brown. Scape slightly broader than pedicel with 3–5 median unequal setae, pedicel with 4–6 setae scattered on distal 1/2; flagellomeres moderately long with short but distinct neck; flagellar hairs short about 1/4 × diameter of flagello-

*Department of Zoology, Presidency College, Calcutta 700 073.



Figs. 1-11. *Phytosciara* (*Dolichosciara*) *insignituberosa* n. sp. ♂1. eye bridge, 2. palpus, 3. flagellomere, 4. wing, 5. fore tibial comb, 6. tarsal claw, 7. terminalia and aedegus, ♀: 8. flagellomere 4, 9. wing, 10. cerci and 11. vaginal furca.

meres, flagellomere 4 (Fig. 3) 0.1 (0.09–0.12, n=8) long. 1.4 × wide; neck about 1/7 × length of flagellar joint.

Thorax: Acrostrichals moderately developed restricted to 1/2 or slighlty more of scutum, dorsocentrals longer than acrostrichals, supra-alars strong about 3 × dorsocentrals. Scutellum with 5 strong posterior setae, longest one subequal to supra-alars anterior pronotum with 8–11 posterior setae, posterior pronotum bare; proepisternum with 10 setae, proepimerone sharply triangular, posterior mesoepimeron about 1.4 × longer than wide.

Wing (Fig. 4): Brown, entire surface clothed with dense microtrichia; posterior margin with numerous fine setae. Length 2.52 (2.4–2.65; n=8) mm; breadth 1.0 (0.95–1.05, n=8). Costa, sub costa, R_1; R_{4+5}; distal portion of r–m, mistal portion of stM, M_1 & M_2, and CuA_1 with macrotrichia; stM evanescent; anal vein single; M–fork symmetrical, basal 1/2 slightly arcuate. R–M index 1.45 (1.4– 1.56, n=8), C–M 0.62(0.58–0.66, n=8), st Cua/bM 0.88 (0.76–1.03, n=8), r–m/bM 1.2(1.03, n=8), r–m/bM 1.2(1.03 –1.3), n=8). Haltere yellowish brown with 1 row of dorsal and ventral setae.

Legs: Coxa and femur brown with yellowish tint, otherwise dark brown. Fore leg: length of femur 0.7; tibia 0.97 basitarsomere 0.65, 2nd tarsomere 0.25. Hind leg: femur 0.98; tibia 1.48; basitarsomere 0.74, 2nd tarsomere 0.23. Fore tibial setae differentiated by enlarged posterodorsals, few post-medials, dorsals, and 4 strong pre-apical setae, fore tibial comb (Fig. 5) with unilateral row of 6–7 dark, subequal setae contiguous to the tibial vestiture. Mid-tibia with differentiated strong posterior, dorsal, and 6 pre-apical setae. Hind-tibia with distinctly enlarged stout anterodorsal, posterodorsal, dorsal ventral, and 12 apical setae. Tibial spurs 1:2:2; hind tibial spurs 1.9 × longer than diameter of tibial apex. Tarsal claws (Fig. 6) with 4 distinct teeth.

Abdomen: Tergum brownish black, clothed with dense strong and dark coloured setae; sternum little pale, setae slightly shorter; sternum VIII with 3 rows of posterior setae. Terminalia (Fig. 7). Tergum IX subconical with well developed scattered setae, posterior margin with 5–6 more pronounced setae; sternum IX reduced, posteriorly a small triangular papillae bearing a group of short setae. Dorsal apodeme slender extending more than 1/2 way into genital cavity. Ejaculatory apodeme long 2nd well sclerotized with broad apical fork. Aedeagus shield shaped, basal arms strongly sclerotized and projected anteriorly, rest of the surface moderately sclerotized. Tergum X bilobed, lobes squared to slightly rounded at apex, densely setigerous; apical margins with several long setae. Gonocoxites narrowly joined ventrally, clothed with dense long setae; meso apical setae about 1/2 length of gonostylus. Gonostylus with a distinct sub-dorsal protuberance provided with 4 dark, strong and unfused spines, apical region cap-like with densely disposed 7–8 short spinelets; outer margin with 1 more enlarged seta; gonostylus 2.3 × longer than wide and 0.72 × length of gonocoxite.

Female :

Head: Blackish brown, slightly larger than male. Flagellomeres relatively shorter and narrower than male; flagellomere 4 (Fig. 8) 0.06 mm in length. Palpus with similar setal arrangement as male; 1st and 3rd segment little longer.

Wing (Fig. 9): larger than male. Length 3.09 (3.05–3.12, n=4), breadth 1.25 (1.22–1. 29,n=4) R–M index 1.6 (1.55–1.64, n=4)

C–M 0.61 (0.6–0.63, n=4), r–m/bM 1.12 (1.09–1.25, n–4), st Cua/bM 0.83(0.82–0.84, n–4).

Legs: Relatively longer; fore leg: femur 0.83 mm, tibia 1.1 mm; basitarsomers 0.76, 2nd tarsomere 0.26, hind leg; femur 1.1, tibia 1.6 mm, basitarsomere 0.86 mm, 2nd tarsomere 0.26 mm. Setal pattern of fore tibial comb similar to male. Hind tibial spurs 1.95 × longer than diameter of tibial apex.

Abdomen: Longer than male. Terminalia: Cerci (Fig. 10) very short, about 1.6 × length of hypogynal valves., Vaginal furca (Fig. 11) with stem slightly swollen medially, arms medially flattened and joining stem posteriorly.

Type data: **Holotype** ♂ (Type No. *Ent. Ph. I PCZM*) Darjeeling, April, 12, 1978, Coll. S. Alam. **Allotype** ♀, data same as type. **Paratypes** 5 ♂♂ and 3 ♂♂, Silliguri, June 7–8, 1983, and November 10, 1983, Coll). S. Alam.

Remarks: This new species fits in the species group of subgenus, *Dolichosciara* Tuomikoski (1960) and shows resemblances with *P. flavaipes* (Meigen) reported from Formosa, Europe, Afrotropical region and North America, but is readily separable for its relatively wider 4th flagellomere, absence of macrotrichia on CuA_2, gonostylus with prominent subsorsal protuberance bearing 4–spines.

2. Phytosciara (Prosciara) bituberosa, n. sp. (Figs. 12–22)

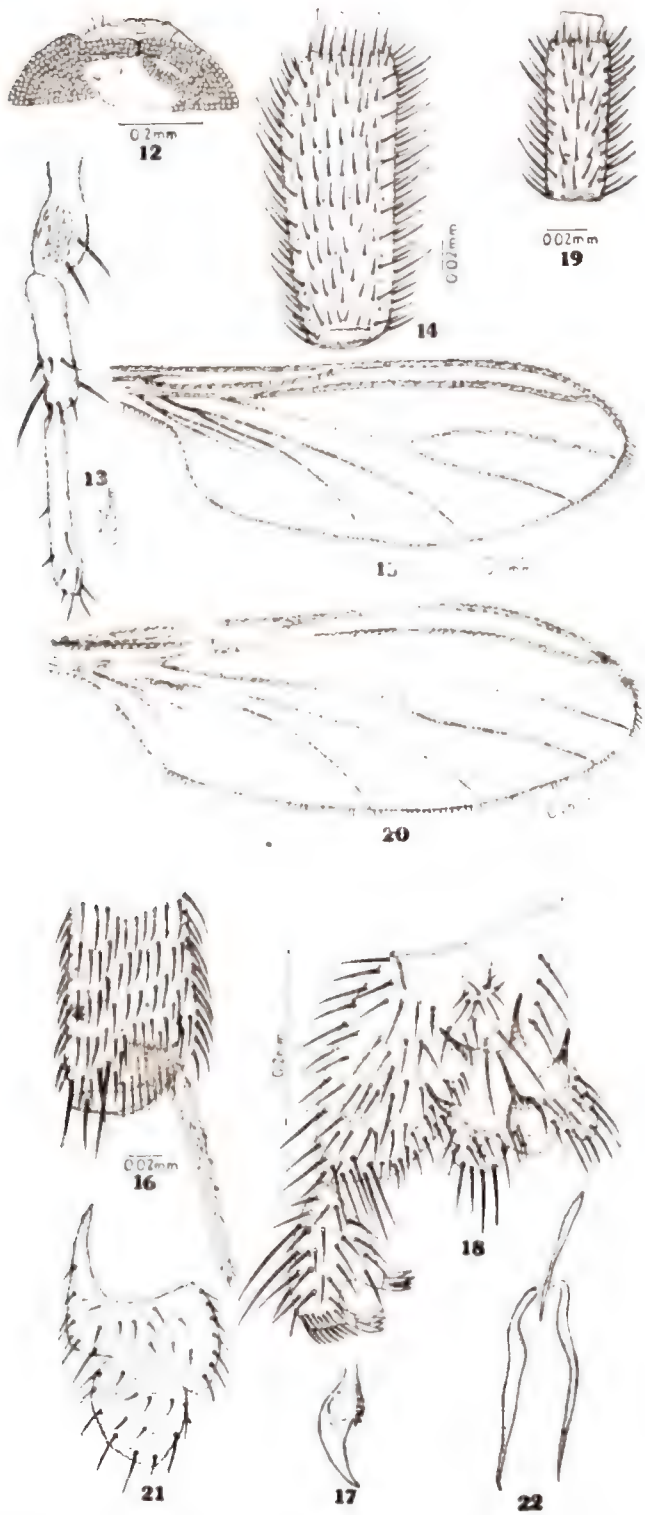
Male:

Head Blackish brown ovoid; length 0.44 (0.43–0.46, n=6). Interfacetal hairs abundant; extending slightly beyond outer curvature of facets. Eye bridge (Fig. 12) contiguous and broad, junction with 2 facets long. Median ocellus with 3 strong bristles separated from eye bridge by about width of 1 ocellus. Anterior vertex about 1/4 length of head with 7–10 strong scattered setae, posterior vetex dark with numerous setae subequal to slightly larger than anterior vertexal setae. Prefrons with 3 stout ventral and 19–22 scattered weak setae. Clypeus with 2 median setae. Labrum short, subtriangular. Probosics about 1/3 length of head. Labellum moderately developed, total width of labellar lobes subequal to the length of proboscis.

Palpus (Fig. 13): Pale brown, 3-segmented; pp. 41.8: 35.0: 51.0; Segment 1 somewhat swollen at distal 1/2 with blunt apex, a dorsal patch of numerous hyaline sensillae, distal 1/3 with 2 dorsolateral setae; segment 2 cylindrical, about 0.8 × length of 1st segment, with 8–9 setae of which 1 dorsolateral greatly enlarged; segment 3 narrowed and elongate, about 1.2 × length of 1st segment, with 10 setae disposed on distal 1/2.

Antenna: Yellowish brown. Scape ovoid, distinctly broader than pedical with 1 long and 2 moderate-sized median setae; pedicel globose with 9–11 weak scattered setae. Flagellomeres long, segments along distal 2/3 relatively narrower and longer; neck short but distinct, flagellar hairs pale, about 1/3 width of flagellomeres, flagellomere 4 (Fig. 14) 0.14 (0.13–0.15, n=6) mm long, about 3 × as long as wide; neck 1/6 to 1/7 length of flagellar joint.

Thorax: Deep brown with blackish tint. Acrostrichals medium-sized, scattered on anterior 1/2 of scutum, dorsocentrals subequal to little longer than acrostrichals, supra-alars long and strong, longest one about double the dorsocentrals. Scutellum with 6–7 weak scattered and 4 strong



Figs. 12–22. *Phytosciara* (*Proscira*) *bituberosa* n. sp. ♂12. eye bridge, 13. palpus, 14. flagellomere 4, 15. wing, 16. fore tibial comb, 17. tarsal claw, 18. terminalia and aedeagus, ♀: 19. flagellomere 4, 20. wing, 21. cercus and 22. vaginal furca.

posterior setae. Posterior bare, anterior pronotum with 1–2 ventroposterior and 6–7 dorsal scattered setae. Proepisternum with 4 moderate-sized setae. proepimerone broadly triangular; posterior mesoepimeron about 2.5 × longer than wide.

Wing (Fig. 15): Brown, covered with dense and pale microtrichia; posterior margin with many fine setae. Length 2.74 (2.6–2.87, n=6), breadth 1.02 (0.95–1.05, n=6). Costa, R_1, R_{4+5}, distal portion of r–m with macrotrichia, posterior veins bare; M–fork symmetrical; stM evanescent. R–M index 1.72 (1.55–1.84, n=6), C–M 0.52 (0.51–0.55, n=6), r–mbM 1.41) (1.06–1.33, n=5), st CuApbM 0.78(0.66–1.0, n=6). Haltere light brown, knob with diagonal row of dorsal setae.

Legs: Coxa and femur pale yellow with brownish tint, rest of the segments brown with yellowish tint. Fore leg: length of femur 0.97; tibia 1.43; basitarsomere 1.1; 2nd tarsomere 0.4. Hind leg: femur 1.22; tibia 2.63; basitarsomere 1.02; 2nd tarsomere 0.34. Fore tibial setae differentiated by 3 enlarged anterior, 3 postmedial dorsal, and 4 strong preapical setae; fore tibial comb (Fig. 16) with 1 row of 7 dark enlarged setae contiguous to general tibial vestiture. Mid-tibial setae differentiated by several enlarged posterior, dorsal, and 6 stout preapical setae. Hind tibial setae well differentiated, several strong and dark posterodorsal, anterodorsal, ventral and 1 row of 15 preapical setae. Tibial spurs 1:2:2; hind tibial spurs greatly enlarged, about 2.18 × longer than diameter of tibial apex. Tarsal claws (Fig. 17) with short recurved teeth.

Abdomen: Tergum brownish yellow, clothed with dense and strong setae; sternum pale with weak and slightly shorter setae, sternum VIII with 3 rows of posterior setae. *Terminalia* (Fig. 18). Tergum IX conical, posterior margin with 2 enlarged setae, rest of the surface with shorter scattered setae, sternum IX reduced with a patch of weak setae. Dorsal apodeme narrow, strongly sclerotized anteriorly and extending about 1/2 way into genital. Ejaculatory apodeme slender and long with 'U' shaped apical fork. Aedeagus sub conical, basal arms anteriorly projected and strongly sclerotized, lightly sclerotized on remainder. Tergum X bilobed with rounded apex, numerous minute setae scattered all over the surface except for several long setae at apical margins. Gonocoxites broadly joined clothed with numerous setae; setae on the mesoapical region slightly enlarged, about 1/2 the length of gonostylus; setae along mesal surface short, weak and more in number; gonostylus with 1 distinct dorsomesal and 1 shorter mesoapical protuberance, each with 4 closely set to fused stout and dark spines; apex with a dense bunch of short spinelets; outer dorsomedian surface with 2 well differentiated enlarged setae; gonostylus 1.46 × longer than wide and 0.47 × length of gonocoxite.

Female:

Head: Brown slightly smaller than male. Flagellomeres relatively shorter and narrower than male; flagellomere 4 (Fig. 19) 0.08 mm long, about 0.6 × length and width almost 1/2 of male. Palpal segments slightly shorter; pp. 37.5: 31.0: 50.5.

Wing (Fig. 20): Larger than male. Length 3.47 (3.2–3.75, n=4); breadth 1.22 (1.15–1.3, n=4). R–M index 1.65 (1.5–1.8, n=4), C–M 0.54(0.5–0.56, n=4) r–m/bM 1.2(1.15–1.25, n'=4), st CuA/bM 0.93 (0.92–0.94, n=4).

Legs: Fore leg: femur 1.16; tibia 1.7; basitarsomere 1.24; 2nd tarsomere 0.48; hind leg; femur 1.42; tibia 2.2mm; basitarsomere 1.2; 2nd tarsomere 0.4.

Fore tibial comb with 1 row of 5 dark setae contiguous to general tibial vestiture. Hind tibial spurs 2.4 × longer than diameter of tibial apex. Tarsal claws similar to male.

Abdomen: Longer than male. Cercus (Fig. 21) short and broad, about double the length of hypogynal valves. Vaginal furca as figured (Fig. 22), stem elongate; arms dorsomedially flatterned and joining the stem at posterior quarter.

Type data: **Holotype** ♂ (Type no. *Ent Ph* 3 *PCZM*) Darjeeling, April 16, 1987, Coll. S. Alam. **Allotype** ♀ data same as type. **Paratypes** 5 ♂♂ and 2 ♀♀ Darjeeling, June 2–3, 1983, Coll. S. Alam. 2 ♂♂ and 1 ♀ Siliguri, May, 10, 1973, Coll. P. K. Chaudhuri.

Remarks: This new species is somewhat closer to the Hawaiian species *P.* (*Prosciara*) *vulcanata* Steffan in the setal number on 1st palpal segment, structure and setal arrangement of flagellomeres, wing venation including macrotrichial arrangements, and toothed claws, but readily separated by its higher R–M index (1.72), distinctly lower C–M index (0.52), presence of 7 setae in fore tibial comb, and 2 subdorsal protuber-cances provided with closely set spines.

ACKNOWLEDGEMENT

The authors are indebted to Dr. W. A. STEFFAN, Idaho State Museum (U. S. A.) for providing pertinent literature for this study. Sincere thanks are due to the Heads of the Departments of Zoology, Presidency College, Calcutta and University of Burdwan for laboratory facilities.

REFERENCES

ALAM, S., S. K. DASGUPTA & P. K. CHAUDHURI (1987) Indian species of *Corynoptera* Winnertz (Sciaridae: Diptera). *Tidjdschr. V. Ent.*, **130** (in press).

FREY, R. (1942) Entwurf einer neuen Klassifikation der Miickenfamile Sciardiae (Lycoriidae). *Notul. Ent.*, **22**, 5—44.

STEFFAN, W. A. (1972a) Family Sciardae, 464–476, *in: A Catalogue of Diptera of the Oriental Region. Vol.* 1 Univ. Hwaii Press., (Delfinado, M. and Hardy, D. E., eds.).

STEFFAN, W. A. (1972b) Oriental Sicaridae (Diptera) 1. Redescription and review of species described by Edwards and Brunetti. *Pacif. Ins.*, **14** (3), 589—605.

STEFFAN, W. A. (1984) A new species of *Plastosciara* (Diptera: Sciaridae). *Proc. Ent. Soc. Wash.*, **86**(2), 287—290.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 117 to 120

OBSERVATIONS ON INSECTS ASSOCIATED WITH THE WATER YAM, *DIOSCOREA ALATA* L. DURING STORAGE, WITH PARTICULAR REFERENCE TO LEPIDOPTERAN PESTS

E. U. IHEAGWAM & J. WOJTUSIAK[1]
Department of Zoology, University of Nigeria, Nsukka, Nigeria

(*Received* 31 *March* 1988)

Insects in the families Tineidae and Pyralidae (Lepidoptera), Anthribidae (Coleoptera), Stratiomyidae (Diptera) and Chalcididae (Hymenoptera) emerged from the pulp of stored tubers of the water yam, *Dioscorea alata*. Tubers with cut surfaces (wounds) were more prone to attack by the moths than tubers with unbroken skin, possibly because the tender first instar larvae were unable to penetrate through the skin of the latter. Damage to tubers was done by the larval stages which fed voraciously and extensively within the tuber. Signs of infestation were visible externally as holes which were filled with larval faecal matter (frass) held together by silken thread produced by the larvae themselves.

(*Key words:* water yam insects)

INTRODUCTION

Yams (*Dioscorea* spp.) are primarily plants of the tropical regions although some species are found in the temperate parts of the world. They constitute an important staple food in West Africa where more than half of the world's yams are produced. Nigeria alone produces over three-quarters of the total world production of yam (COURSEY, 1967; ONWUEME, 1978).

Yams are stored after harvesting for two main reasons. Firstly, to provide seed for the next planting season and secondly, to make them available for human consumption during famine or dearth. In Nigeria, yearly storage losses as high as 40% have been reported (WAITT, 1961). In West Africa, over one million tonnes of yam tubers are lost annually during storage (COURSEY, 1965).

Some factors that contribute to the biodeterioration of stored yam tubers include mechanical damage, changes in their general biochemistry and physiology (IKEDIOBI, 1985; OSUJI & UMEZURIKE, 1985), insect, mammalian and microbial attacks.

Storage rots resulting from microbial activity is one of the major causes of yam losses. Losses due to insect pests, though enormous, have not received as much attention as those due to microbes. Although references have been made by some authors to some coccids and mealybugs as the most serious insect pests of yam tubers during storage, damage to tubers by moth is, at the moment, by far more serious than that by any other insect pest of stored yams.

The aim of this paper was to show the range of insect species associated with the pulp of *D. alata* during storage and to emphasize the nature and extent of damage to yam tubers by the moths.

MATERIALS AND METHODS

Tubers of *D. alata* in storage at Nsukka and Umuahia areas of south-eastern Nigeria were sampled between January and July in 1975 and 1976. The sampling was done

[1]Zoological Museum, Jagiellonian University, Karasia 6, 30-060, Krakow, Poland.

to ascertain the condition of the tubers before and after attack by moths. Some infested yam tubers were brought back to the laboratory where insects that inhabited the interior of the tubers were reared out and apsects of the behaviour and economic importance of some of them studied.

RESULTS AND DISCUSSION

In his preliminary work on the entomofauna of *D. alata*, IHEAGWAM (1986) listed only two tineids among other insect groups. Further studies have revealed the involvement of other tineids in the biodeterioration of *D. alata* during storage. The insects that are associated with *D. alata* as pests or otherwise are listed in the Table.

Our survey revealed that yam tubers with broken surfaces, i.e., wounds (Fig. 1) were more prone to moth attack than those with intact surfaces. This was so possibly because the mandibles of the first instar larvae are generaly too feeble to cut through the hard skin of the tubers but strong enough to nibble their way through the wounds into the pulp. Thus they depend largely on mechanical injureies on yam tubers for their establishment. DINA (1977), in his rearing experiments of *D. rugosella*, used wounded yam tubers by making incisions of about 2 cm deep in yam tubers and introduced the first instar larvae which burrowed sucessfully into the tubers.

Tubers of *D. alata* acquire wounds in various ways. Mechanical damages may be inflicted on tubers during the process of digging them out from the ground. *D. alata* is generally harvested during the dry season (November or December) and with the hard soil, tubers are more prone to damage especially if they are large. Breakage or abrasion of yam tubers may occur during their transportation from the field to the barns or to the markets. Nematodes such as the root-knot nematode, *meloidogyne* spp., the root lesion nematode *Pratylenchus* spp., and *Scutellonema bradys* may play an important role in the infestation of yam tubers by yams moths, by virtue of their serious destruction of field and stored yam tubers.

We do not yet know how the moths are able to locate damaged tubers, but we think they do so visually. It well may be also

TABLE 1. Insects associated with the interior of stored *Dioscorea alata*.

Order	Family	Scientific name	Authority
Lepidoptera	Tineidae	*Dasyses incrustata*	MEYRICK
"	"	*Dasyses rugosella*	STAINTON
"	"	*Setamorpha rutella*	ZELLER
"	"	*Gephyristis certa*	MEYRICK
"	"	*Phaeoses sp.*	
"	Pyralidae	*Euzopherodes vapidella*	MANN
Coleoptera	Anthribidae	*Araecerus fasciculatus*	DEGEER
Diptera	Stratiomyiidae	*Gobertina picticornis*	BIGOT
Hymenoptera	Chalcididae	*Epitranus inops*	STEFFAN

Fig. 1. Tubers of *D. alata* in the "barn".
Centre tuber shows wounds with signs of moth infestation.

that wounded tubers emit certain odours which, when perceived by the insects, attract them to such tubers.

Eggs are laid on any part of he tuber but preferably in the vicinity of the wound. On hatching, the larvae nibble their way into the tuber through the wound. The larval stages, e.g., of *D. rugosella* feed voraciously as evidenced by the large accumulation of frass in the tuber. Extensive damage is done to the tuber as the larvae feed. The degree of damage may be accentuated by secondary infection by micro-organisms.

Signs of yam tuber infestation by the moths are visible on the surface of tubers in the form of holes filled with small black granules of larval faecal matter which are held together and suspended by silken threads which are produced by the larvae of all instars.

These silken threads with the frass often form black tubes hanging down from the surface of the tubers and are not only characteristic signs of infestation but also places of emergence of adults from the pupae. The faecal materials are believed to play an important role in protecting the larvae against parasites as they make it difficult for parasites to penetrate into the feeding sites of the pest.

Survey of *D. alata* on sale in markets at Nsukka in 1986 showed that moth infested tubers rose from 1.0% in early February to 56% in late June (EZIKE, 1987).

DINA (1977) recommended that *D. alata* be harvested early enough before the soil dries out and harden, so as enhance the production of wholesome tubers which could be stored without the risk of moth infestation. In addition, infestation of tubers of *D. alata* by yam moths could be checked by ensuring that both slightly and seriously wounded tubers are excluded from storage systems.

Stratiomyid larvae are either carnivorous or saprophagous. Work is still in progress to establish whether *Gobertina picticornis* predates on the rest of the insect fauna in the yam tuber or whether it feeds on the decaying part of infested tubers. As for *Epitranus inops*, it is a parasite of *Gobertina picticornis* (personal ommunication G. S. Robinson).

ACKNOWLEDGEMENTS

We are grateful to Dr. GADEN S. ROBINSON of the British Museum (Natural History), London, for identifying the yam tuber insects. This work was supported by a Senate Research Grant of the University of Nigeria to the senior author.

REFERENCES

COURSEY, D. G. (1965) The role of yams in West African economies. *Wld Crops*, **17** (2), 74–82.

COURSEY, D. G. (1967) *Yams*. Longmans, London, 230 pp.

DINA, S. O. (1976) Occurrence of *Dasyses rugosella* Stainton (Lepidoptera: Tineidae) on stored yam tubers in Nigeria. *Trop. Sci.*, **19**(2), 113—116.

EZIKE, C. I. (1987) Studies on the bionomics of *Dasyes rugosella* Stainton (Lepidoptera, Tineidae) - a storage pest of *Dioscorea* spp. M. Sc. thesis, University of Nigeria, Nsukka.

IHEAGWAM, E. U. (1986) Preliminary observations on the entomofauna of the water yam *Diosocrea alata* L. during storage. *D tsch. ent.* N. F., 33 (1–2), 71—73.

IKEDIOBI, C. O. (1985) Biochemistry and physiology of yam storage, *in: Advances in Yam Research* (Ed. G. OSUJI) Frontline Publishers, Enugue Nigeria.

ONWUEME, I. C. (1978) *The Tropical Tuber Crops*. John Wiley & Sons Ltd., New York, 234 pp.

OSUJI, G. O. & G. M. UMEZURIKE (1985) The biochemistry of yam tuber deterioration, *in: Advance in Yam Research* (Ed. G. OSUJI). Frontline Publishers, Enugu, Nigeria.

WAITT, A. W. (1961) Review of yam research in Nigeria, 1920—61. *Fed. Agric. Res. Memo.* No. 31.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 121 to 126

THREE NEW SPECIES OF *ACULOPS* KEIFER (ACARI: ERIOPHYIDAE) FROM WEST BENGAL, INDIA WITH KEY TO INDIAN SPECIES

N. K. GHOSH[1] & S. CHAKRABARATI
Biosystematics Research Unit, Department of Zoology,
University of Kalyani, Kalyani, India 741 235

(*Received* 2 *October* 1987)

Three new species of *Aculops* Keifer viz., *A. dilleniae* infesting *Dillenia indica* Linn., *A. ichnocarpi* infesting *Ichnocarpus frutescens* R. Br. and *A. morindae* infesting *Morinda persicaefolia* Ham. are described. Relationships of the new species with other known species under the genus are discussed. A key for separating the Indian species has also been provided.

(*Key words:* Acari, Eriophyidae, taxonomy, new species, West Bengal, India)

INTRODUCTION

The genus *Aculops* Keifer (1966) among the genera under the subfamily Phyllocoptinae is characterised by the shield with acuminate anterior lobe, dorsal tubercles placed on rear margin of shield or projecting over it and dorsum of thanosome evenly arched, lacking any ridge or furrow. So far, 75 species of *Aculops* including 12 from India are known. Mohanasundaram (1981) provided a key of 8 species occurring in India. In this paper 3 new species mentioned in abstract are described from West Bengal, India. Here, a key for separating 15 species so far known from India is also provided.

The type slides are deposited presently in the collections of Biosystematics Research Unit, Department of Zoology, University of Kalyani, Kalyani 741 235, India.

1. **Aculops dilleniae** sp. nov. (Figs. 1–8)

Female. Body 121–162* long, 46–48 wide; fusiform; light brown in colour. Rostrum 16–19 long, curved down; subapical seta minute. Shield subtriangular; 28–32 long, 39–42 wide with an anterior lobe; shield design represents network of lines and cells; median line present on rear 0.5 part of shield; admedians complete, somewhat sinuate and meet by cross lines with submedians at 0.25 and with median at 0.5 and 0.75 part of rear shield; submedians forming 3 cells in single tier; the area ahead of dorsal tubercles with obscure dashes; postero-lateral part of shield bears lines of granules and partial rings laterad to dorsal tubercles; dorsal tubercles 9–11 apart, set on rear shield margin, setae 16–19 long, directed to rear. Fore-leg 23–26 long from the base of trochanter; femur 8–9 long, seta 5–7 long; patella 3–4 long, seta 23–25 long; tibia 3–5 long, seta 5–7 long; tarsus 4–5 long, upper setae 16–19 long. lower seta short; claw 8 long; featherclaw simple, 6-rayed. Hind-leg from the base of trochanter 22–23 long; femur 8–9 long, seta 5–7 long; patellar seta 7 long; other characters as in fore-leg. Coxae with granules; sternal line distinct; first coxal tubercles placed at the level of anterior coxal approximation; second tubercles a little ahead of the level of third tubercles.

[1]Correspondence: Dr. S. Chakrabarti.
*All measurements are in micrometer (μm).

Abdomen with 36–38 broad tergites having sparsely set microtubercles and 59–68 sternites with closely set microtubercles; microtubercles bead-like, resting on ring margin; telosomal rings microstriated ventrally. Lateral seta 7–11 long, on sternites 9–10; first ventral seta 18–23 long, on sternites 23–27; second ventral seta 3–5 long, on sternites 31–34; third ventral seta 11–16 long, on ring 5 from rear end; accessory seta absent; caudal seta 21–30 long. Genitalia 11–13 long, 16–19 wide; cover-flap with 16–18 longitudinal lines; genital seta 7–9 long.

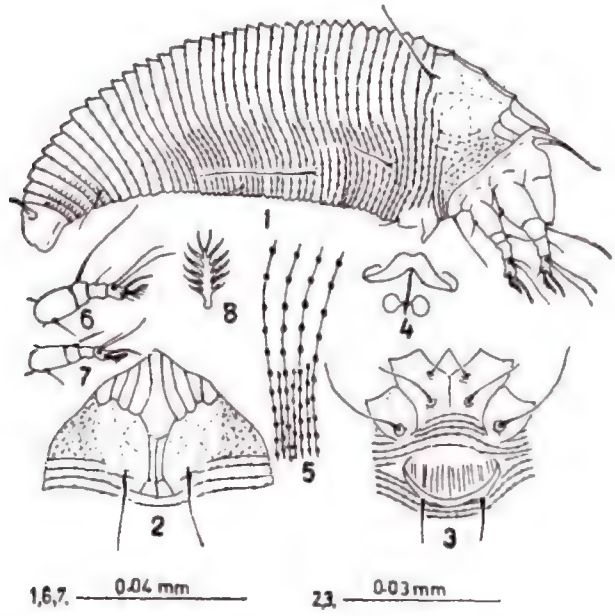
Male : Not seen.

Holotype: Female (marked), on slide (No. 902/47/85), INDIA: WEST BENGAL: Purulia, Pyrachali, 10.xii.1985 from *Dillenia indica* Linn. (Dilleniaceae), coll. N. K. Ghosh.

Pratypes: 7 females on the slide bearing holotype and 32 females on 3 slides (Nos. 903, 905. 910/47/85), collection data as in the holotype.

Relation to host: This species inhabits on ventral surface of leaves without showing any appreciable damage symptom.

Remarks: This species in having 6-rayed featherclaw, microtuberculated tergites, granular coxae, distinct sternal line and incomplete median shield line is close to *Aculops gutierrezi* Keifer (1973) and *A. amnis* Keifer (1979). However, it differs from both the above species by large number of longitudinal ribs on female genital cover-flap, absense of accessory seta and very short second ventral seta. It also differs from *gutierrezi* in lacking basal granular lines on female genital coverflap and from



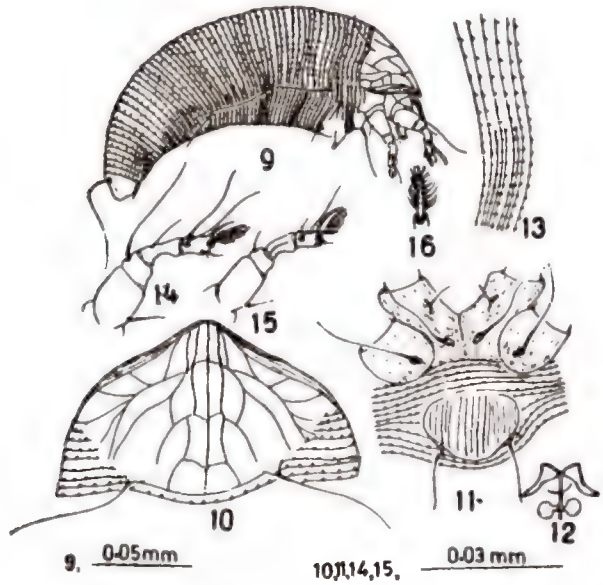
Figs. 1–8. *Aculops dilleniae* sp. nov. Female. 1. Lateral view, 2. Dorsal shield, 3. Coxae with female genitalia, 4. Internal female apodeme, 5. Side skin structure, 6. Fore-leg, 7. Hind-leg, 8. Featherclaw.

amnis by the position of first coxal tubercles at the level of anterior coxal approximation.

2. **Aculops ichnocarpi** sp. nov. (Figs. 9–16)

Female: Body 158–200 long, 60–66 wide; robust, fusiform; brown in colour. Rostrum 16–20 long, curved down; subapical seta 5–6 long. Shield 35–42 long, 51–58 wide; subtriangular with an acute anterior lobe; shield design represents network of lines; median line complete; admedian lines complete, sinuate, intersected by cross lines at 0.3, 0.6 and 0.8 part of shield; first submedians cross the anterior cross line at 0.33 part and fork at 0.4 part of shield, the inner branch meets with incomplete middle cross line and outer branch runs posterolaterally; anterior cross line extending back and form 5–6 cells with lateral line; anterolateral shield margin with obscure dashes; dorsal tubercles located on rear shield margin, 23–28 apart; setae 19–23 long, directed caudad. Fore-leg 29–36 long from the base of trochanter; femur 9–12 long, seta 8–10 long; patella 4–6 long, seta 19–23 long; tibia 6–8 long, seta 6–7 long; tarsus 5–7 long with two upper setae, each 21–25 long, lower seta 5 long; claw 7 long; featherclaw simple, 8–rayed. Hind-leg 25–30 long from the base of trochanter. Forecoxae with short sternal line; both the coxae ornamented with dotted lines and granules first coxal tubercles placed ahead of the anterior coxal approximation; second tubercles located little ahead of line through the third tubercle.

Abdomen with 54–58 tergites and 72–80 sternites; tergites broader than sternites and less conspicuously microtuberculated; microtubercles on tergites elongated but on sternites bead-like and set on ring margin ; telosomal rings microstriated ventrally. Lateral seta 23–30 long, on sternites 10–12; first ventral seta 32–35 long, on sternites 26–29; second ventral seta 21–28 long, on sternites 42–44; third



Figs. 9–16. *Aculops ichnocarpi* sp. nov. Female. 9. Lateral view, 10. Dorsal shield, 11. Coxae with female genitalia, 12. Internal female apodeme, 13. Side skin structure, 14. Foreleg, 15. Hind-leg, 16. Featherclaw.

ventral seta 21–28 long, on ring 6–7 from rear end; accessory seta 5–7 long; caudal seta 60–65 long. Genitalia 12–18 long, 21–24 wide; coverflap with 14–16 longitudinal lines; genital seta 12–14 long.

Male: Not seen.

Holotype : Female (marked), on slide (No. 932 / 53 / 85), INDIA : WEST BENGAL: Purulia, Salpara, 29. xii. 1985 from *Ichnocarpus frutescens* R. Br. (Apocynaceae), coll. N. K. Ghosh.

Paratypes : 6 females on the slide bearing holotype and 24 females on 3 slides (Nos. 933–935/53/85), collection data as in the holotype.

Relation to host : This species was found on the ventral surface of leaves and on tender stem without showing any damage symptom.

Remarks: This species resembles *Aculops tephrosiae* Keifer (1962), *A. bassiae* Keifer (1971), and *A. caesalpiniae* Keifer (1977) in having 8-rayed featherclaw, microtuberculated tergites, simple claw, ornamented coxae and female genital coverflap with longitudinal scorings. But the present species remains distinct from all the above three species by the position of its first coxal tubercles which are ahead of anterior coxal approximation, non-granular lateral shield margin and number of scorings on the female genital coverflap. In addition, it also differs from *tephrosiae* and *caesalpiniae* by its complete median shield line and from *bassiae* by its shield design.

3. **Aculops morindae** sp. no. (Figs. 17–24)

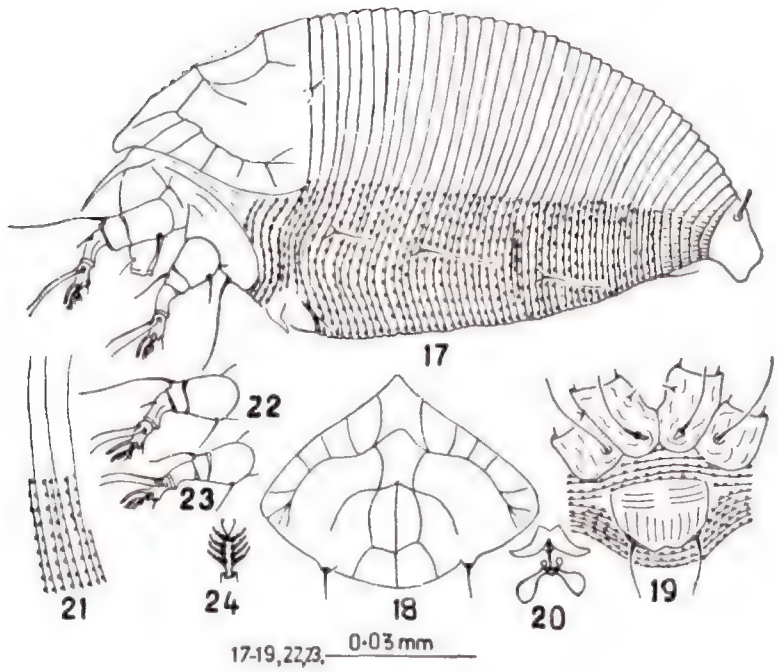
Female : Body 125–140 long, 58–64 wide; fusiform; light brown in colour. Rostrum 20–23 long, curved down; subapical seta 3–5 long. Shield 35–42 long, 56–60 wide; subtrianagular with a short apically pointed anterior lobe; median line present on rear 0.5 part of shield and connect by cross lines with admedians at 0.5 and 0.75 part of rear shield; admedians sinuate; submedians forming 6–7 cells in single tier at the anterolateral shield margin; dorsal tubercles on rear shield margin, setae 6–8 long and directed to rear. Foreleg 23–30 long from the base of trochanter; femur 9–11 long, seta 10–12 long; patella 3–5 long, seta 18–25 long; tibia 4–6 long, seta 3–5 long; tarsus 4–6 long, upper setae 18–21 long, lower seta short; claw 6–7 long; featherclaw simple, 5-rayed. Hindleg from the base of trochanter 21–26 long; femur 8–9 long, seta 9–12 long; patellar seta 9–11 long; other characters as in foreleg. Forecoxae with weak sternal line; first coxal tubercles set ahead of anterior coxal approximation; second tubercles a little ahead of line across third tubercles; coxae ornamented with curved lines.

Abdomen with 37–40 smooth tergites and 67–75 microtuberculated sternites; microtubercles bead-like, resting on ring margin. Lateral seta 19–23 long, on sternite 8–10; first ventral seta 32–39 long, sternite 19–22; second ventral seta 27–30 long, on sternite 38–42; third ventral seta 21–24 long, on ring 6 from rear; accessory seta absent; Caudal seta 28–32 long. Genitalia 12–14 long, 16–19 wide; coverflap basally with 3 transverse lines and distally with 8–10 longitudinal ribs; genital seta 14–16 long.

Male : Not seen.

Holotype : Female (marked), on slide (No. 857/33/85), INDIA : WEST BENGAL: Purulia, Hura forest, 6. vii.1985 from *Morinda persicaefolia* Ham. (Rubiaceae), coll. N. K. Ghosh.

Paratypes : 2 females on the slide bearing holotype and 28 females on 3 slides (Nos. 858–860/33/85), collection data as in the holotype.



Figs. 17–24. *Aculops morindae* sp. nov. Female. 17. Lateral view, 18. Dorsal shield, 19. Coxae with female genitalia, 20. Internal female apodeme, 21. Side skin structure, 22. Fore-leg, 23. Hind-leg, 24. Featherclaw.

Relation to host : This species inhabits on ventral surface of leaves along with another eriophyid species, *Diptilomiopus* sp. No remarkable damage was noticed on the host plant.

Remarks: Among the species of the genus *Aculops* Keifer having 5-rayed featherclaw, the present species comes close to *A. pittosporae* Mohanasunadram (1981) by non-granular shield margin, smooth tergites and absence of accessory seta but it differs from the latter by the presence of median shield line, ornamented coxae, female genital coverflap with basal transverse scorings, first coxal tubercles ahead of anterior coxal approximation. It also resembles *A. privae* Mohanasundaram (1980) by incomplete median shield line, ornamented coxae and basal design of female genital coverflap but differs from *privae* by smooth shield margin and tergites, absence of accessory seta and location of first coxal tubercles.

KEY TO INDIAN SPECIES OF *ACULOPS* KEIFER

Female:

1. Featherclaw 4-rayed 2
– Featherclaw more than 4-rayed..... 3
2. Median shield - line absent, coxae smooth, tergites smooth, accessory seta absent, genital coverflap with 6 faint longitudinal lines in single tier, on Acanthaceous weed..... ..... *acanthae* Mohanasundaram.
– Median shield line present, coxae with lines of granules and dashes, tergites microtuberculate, accessory seta present, genital coverflap with 3 basal transverse and 12 distal longitudinal lines, on *Salix* sp..... ..... *niphocladae* Keifer.
3. Featherclaw 5-rayed 4
– Featherclaw more than 5-rayed.....11
4. Shield area clear, coxae smooth, on *Betonica* sp..... *betonicae* Mohanasundaram.
– Shield area with lines, coxae smooth or ornamented 5

5. Median shield line absent, coxae smooth..... 6
– Median shield line present, coxae ornamented. 7
6. Shield only with incomplete admedian lines, accessory seta present, claw simple, genital coverflap with 10 lines, on Leguminous creeper. ..... *leguminae* Mohanasundaram.
– Shield with netwrok of lines, accessory seta absent, claw knobbed, genital coverflap with 12–14 .lines, on *Pittosporum floribundum* W. & A.....*pittosporae* Mohanasundaram
7. First setiferous coxal tubercles placed at the same level or a little below the anterior coxal approximation..... 8
– First setiferous coxal tubercles placed ahead of anterior coxal approximation..... 9
8. Median shield line complete, lateral shield margin not granulated, genital coverflap with 9–10 longitudinal lines, accessory seta absent, on *Solanum xanthocarpum* Schrad & Wendle... .....*xanthocarpi* Mondal and Chakrabarti
– Median shield line incomplete, leteral margin of shield with granules, genital coverflap with 11–14 longitudinal lines, accessory seta present on *Boerhaevia diffusa* L. ....*boerhaevtae* Mohanasundaram
9. Coxae with lines and granules; median shield line complete genital coverflap without basal transverse lines, on *Excoecaria agallocha* L. .....*exocoecaria* Mondal and Chakrabarti
– Coxae with curve lines or scorings, median shield line incomplete, genital coverflap with 3 basal transverse lines 10
10. Tergites microtuberculate, accessory seta absent, genital coverflap with 12–14 longitudinal lines, on *Priva leptostachya* Juss..... .....*privae* Mohanasundarm
– Tergites smooth, accessory seta absent, genital coverflap with 8–10 longitudinal lines, on *Morinda persicaefolia* Ham. .... *morindae* sp. nov.
11. Featherclaw 6-rayed.....12
– Featherclaw more than 6-rayed.....13
12. Coxae with curve lines, first coxal tubercles located ahead of anterior coxal approximation, tergites smooth, accessory seta present, genital coverflap with 12–14 lines, on *Abutilon indicum* G. Don .... *abutiloni* Mondal and Chakrabarti
– Coxae with granules, first coxal tubercles placed at the level of anterior coxal approximation, tergites microtuberculate, accessory seta absent, genital coverflap with 16–18 lines, on *Dillenia indica* Linn. .... *dilleniae* sp. nov.
13. Featherclaw 7-rayed, genital coverflap with 3 basal transverse lines, on *Pergularia extensa* N. E. Br..... *extensae* Mohanasundaram.
– Featherclaw more than 7-ryaed, genital coverflap without basal transverse lines 14
14. Median shield line complete, coxae with lines and granules, tergites microtuberculate, featherclaw 8-rayed, accessory seta present, on *Ichnocarpus frutescens* R. Br. .... *ichnocarpi* sp. nov.
– Median shield line absent coxae smooth, tergites smooth, featherclaw 10-rayed, accessory seta absent, on unidentified plant ....*webpenetrans* Mohanasundaram

ACKNOWLEDGEMENTS

The authors are thankful to the University Grants Commission, New Delhi for financial assistance and to the Head, Department of Zoology, University of Kalyani for providing laboratory facilities.

REFERENCES

KEIFER, H. H. (1962) Eriophyid series B-6. *Bur. Ent. Calif. Dept. Agri.*, 1–20.

KEIFER, H. H. (1966) Eriophyid series B-21. *Bur. Ent. Calif. Dept. Agri.*, 1–20.

KEIFER, H. H. (1971) Eriophyid series C-5. *Ent. Res. Div.* ARS, USDA, 1-24.

KEIFER, H. H. (1973) Eriophyid series C-8. *Ent. Res. Div.* ARS, USDA, 1–24.

KEIFER, H. H. (1977) Eriophyid series C-13. *Ent. Res. Div.* ARS, USDA, 1–24.

KEIFER, H. H. (1979) Eriophyid sreries C-16. *Ent. Res. Div.* ARS USDA, 1–24.

MOHANASUNDARAM, M. (1980) Four new species of eriophyids from South India. *Oriental Ins.*, **14** (3), 371–378.

MOHANASUNDARAM, M. (1981) Four new species of *Aculops* (Acari : Eriophyidae) from South India. *Indian J. Acarol.*, **6**, 1–8.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 127 to 132

TWO NEW SPECIES OF THE GENUS *CARYEDON* SCHONHERR (COLEOPTERA: BRUCHIDAE: PACHYMERINAE) FROM INDIA

SHIV K. SINGAL*
Department of Entomology, Haryana Agricultural University, Hisar, India 125 004

(*Received* 14 *June* 1988)

***Caryedon tejpurensis* sp. nov. and *C. bauhinidus* sp. nov. are described in detail with illustrations of adults and their male genitalia. *C. indus* (Motschoulsky) is redescribed in detail with male genitalia and additional information on its occurrence in India.**

(*Key words:* *Caryedon* Schonherr, two new species, Coleoptera, Bruchidae)

The subfamily Pachymerinae characterised by Bridwell (1929) is represented in India by genera *Caryopemon* Jekel and *Caryedon* Schonherr, latter popularized by the common tamarind or groundnut beetle, *Caryedon serratus* (Olivier). Apart from *C. serratus* eight more species have been studied from India by Arora (1977) and Pajni and Singh (1977). The present two species are different from the species of the genus *Caryedon* already described from India or elsewhere by other workers (Prevett, 1965; Southgate, 1971; Decelle, 1969, 1970, 1973–1975, 1975).

In the present communication genus *Caryedon,* two new species and *C. indus* (Motschoulsky), already reported species, have been described in detail by giving suitable illustration of adults and their male genitalia for easy identification.

Toxonomic descriptions:

Genus *Caryedon* Schonherr

Caryedon schonherr, 1823, Tab. Synopt Fam. Curculion., Isis Von oken 2 : 1134.

Caryedon subgenus Schonherr; Pic, 1913 Coleopterorum Catalogas 55 : 7.

Caryedon : Bridwell, 1929, Proc. ent. Soc. Wash, 31 : 144; Prevett 1929, Ana. Soc. Ent. Fr. (N. S) 1 (3) : 523; Decelle, 1966; Rev. Zool. Bot. afr. 74 : 169; Decelle, 1968, Bull. et. Ann. Soc. r. Ent., Belg. 104, 424; Southgate, 1971, Bull. ent. Res. 60: 409–414; Vazirani, 1974, Jour. Bomb. nat. Hist. Soc. 72 (3) : 753; Decelle, 1975, Publ. Cult Co. Diam. Ang. Lisboa. p. 24; Arora, 1977, Oriental Insects Suppl. 7 : 98.

Type species : *C. serratus* (Olivier) 1790

Head short, with malar space not longer than broad; temples not produced; eyes coarsely facetted, emarginate for less than one quarter length, strongly projecting; prothorax flattened, not produced semi-circulary between elytra; scutellum large; elytra convex, elongate, narrowed and deflected apically, covering pygidium base; parameres fused throughout except free parameral tips; endophallic armature consisting of different number of plates.

Caryedon indus (Motschoulsky)

(Figs. 1, 4 A, F, G, H, J,)

Caryaporus indus Motschoulsky, 1858. Etudes ent., 7: 98; Pic 1913, Coleoptererum catalogus 55 : 7.

*Part of Ph.D. Programme.

Pachymerus ceylonicus Pic, 1924, Melanges L' Echange Linnenne, 5 : 25; Decelle, 1973–1975, Ent. scand. suppl. 4 : 190; Vazirani, 1974, Jour. Bomb. nat. Hist. Soc. 72 (3) : 752.

Caryedon languidus Mukerji and Chatterjee 1951, Indian J. ent. 13. 1974.

Pachymerus indus (Motschoulsky) : Vazirani, 1974, Jour. Bomb. nat. *Hist*. Soc. 72 (3) : 752.

Caryedon indus : Decelle, 1973–75. Ent. Scand. Suppl. 4 : 190.

Head light brown to dark brown, constricted behind; frons carinate, its surface minutely pitted and beset with dull white setae; eyes large, bulbous, protruding, slighlty emarginate in front. Antennae slightly longer in male than female, segments 1 to 4 yellowish, cylindrical, segments 5 to 10 dark brown, longer than broad, serrate, segment 11 conical and elongate.

Pronotum brown to dark brown, almost bell shaped, broader than long at base, marginal line complete, its surface pitted and covered with golden setae. Scutellum dark brown, quadrangular, longer than broad, its srurface beset with golden setae. Elytra dark brown, elongate narrow and deflected at apex, covering base of pygidium with humeral callosities moderately developed, its surfacce covered with golden setae. Fore-and middle legs testaceous; hind-legs dark brown, hind-femur flattened, laterally compresed, provided below with a strong tooth behind middle followed 7–8 small teeth towards apex and preceded by widely spaced 4 minute serrulations. Pygidium dark brown, vertical and broader than long in male, subvertical and longer than broad in female, its surface covered over with mixed golden and black setae.

Phallus 1.22 mm long; parameres fused with their free tips divergent and conical, each beset with 5 long setae; endophallic first pair of plates small and triangular, second pair long and triradiate with a single median and two lateral processes, third pair broader at base, tapering, curved apically.

Size large : Length male. 4.90 mm.
Length female. 4.50 mm.

Host-plant. Unknown.

Specimens examined : 2 ♂♂, 3 ♀♀, INDIA: BIHAR : Ranchi. i, 1977; collected from grass underneath *Cassia fistula* (Family Leguminosae) by Shiv. K. Singal.

Caryedon tejpurensis sp. nov.
(Figs. 2, 4 B, E, L, M).

Head dark brown, constricted behind; frons carinate, its surface minutely punctate and beset with golden pubscence; eyes large, bulbous, protruding, slightly emarginate in front. Antennae testaceous, reaching short of middle of elytra, segments 1 to 4 cylindrical, segments 5 to 10 broadened, serrate, segment 11 oblong.

Pronotum dark brown, with its sides angulate near apical third, straight behind angulation, margined with a line all along, its surface coarsely pitted and uniformly covered over with yellowish setae. Scutellum dark brown, quadrangular, slightly longer than broad, its surface covered over with pale, yellow setae. Elytra dark brown, elongate, together more than twice as long as broad, narrow and deflected at apex; humeral callosities moderately developed, elytra covered uniformly with yellow setae. Fore-and middle legs testaceous; hind-legs dark yellowish; hind-femur flattened, laterally compressed, provided below with a strong tooth behind middle, followed by 13 to 14 teeth towards apex and preceded

Figs. 1 (above) male, *Caryedon indus* (Motschoulsky) 2. (left) male, *Caryedon tejpurensis* sp. nov. 3. (right) male *Caryedon bauhinidus* sp. nov.

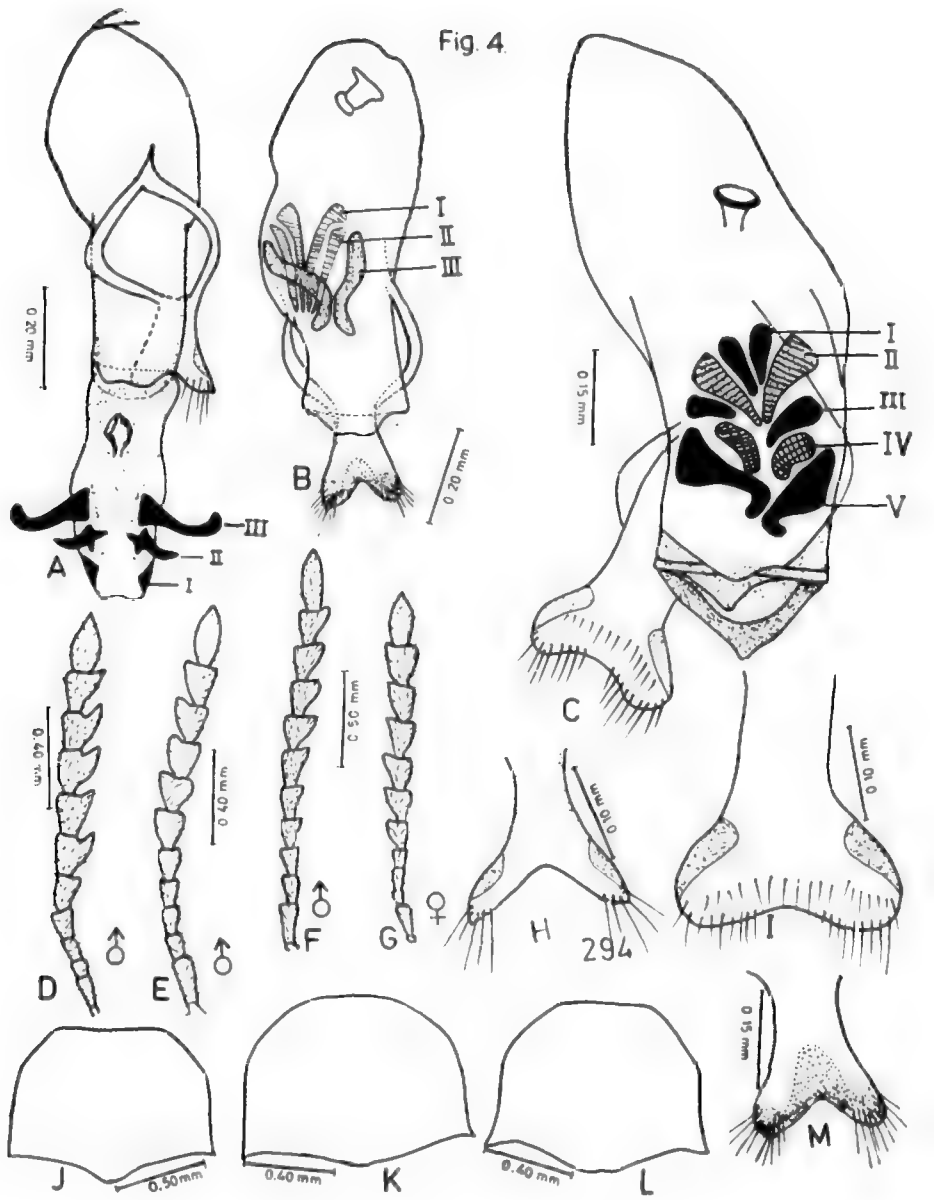


Fig. 4. A, F, G, H, J, *C. indus* (Motschoulsky); A. Phallus, F. Antenna (Male), G. Antenna (Female). H. Paramere, J. Pronotum. 4. B, E, L, M. *Caryedon tejpurensis* sp. nov. B. Phallus, E. Antenna (Male), L. Pronotum, M. Paramere, 4. C, D, I, K, *Caryedon bauhinidus* sp. nov. C. Phallus, D. Antenna (Male), I. paramere, K. Pronotum.

by 6 minute serrulations. Pygidium testaceous, subvertical, longer than broad, its surface covered with pale yellow setae.

Phallus 0.98 mm long; parameres fused with their free tips slightly rounded and divergent, each beset with 8–9 long setae; endophallic first second and third of plates fairly long.

Host plant : Unknown.

Specimens examined : **Holotype** 1 ♂, allotype 1 ♀ INDIA : ASSAM. Charduar forest, Tejpur. iv. 1975, collected from grass by sweeping the net underneath *Cassia* sp. (Fam. Leguminosae) by Shiv. K. Singal.

Remarks : Most of the species of the genus *Caryedon* are yellowish through light brown to dark brown coloured. It is difficult to sort out the different species by external characters like colour or other means. Therefore, the structure of the endophallic armature seems to be most reliable criterion for specific discrimination. The present species, *C. tejpurensis* sp. nov. having size less than 6.50 mm, with antennae unicolourous and three pairs of endophallic plates is closely related to *C. punjabensis* Pajni and Singh. However, it differs from it in having pygidium testaceous and endophallic plates first and second pairs fairly long (pygidium almost black and first and second pairs of endophallic plates small and triangular in *C. punjabensis*. It also differs from *C. indus* (Motschoulsky) which possess bicolorous antennae and first pair of endophallic plates small and triangular second pair long and triradiate besides other variation in tip of phallus and parameres.

Caryedon bauhinidus, sp. nov.
(Figs. 3, 4 C, D, I, K)

Head brownish-yellow, slightly constricted behind; frons carinate, punctate between eyes, its surface adorned with golden pubescence; eyes large, bulbous, protruding, slightly emarginate in front. Antennae testaceous, surpassing base of pronotum, segments 1 to 4 cylindrical, segments 5 to 10 nearly as long as broad, serrate, segment 11 oblong cone.

Pronotum yellowish, broader than long at base, with sides parallel for two thirds length from basal corner than convergent anteriorly, its surface covered uniformly with golden setae. Scutellum brownish-yellow, quadrangular, slightly longer than broad, its surface beset with golden pubescence. Elytra pale yellow, each nearly three times as long as broad, narrow and deflected at apex, with humeral callosities moderately developed, its surface uniformly covered with golden pubescence. Legs testaceous; hind-femur flattened, laterally compressed, provided below with a strong tooth behind middle, followed by seven teeth towards apex and preceded by three well placed serulations. Pygidium pale yellow, subvertical, nearly as long as broad, narrowed towards apex, its surface uniformly covered with golden setae.

Phallus 1.03 mm long; parameres fused with their free tips slightly divergent and rounded, each carrying a number of long marginal setae; endophallic armature consisting of five pairs of plates which differ in number and shape from those of other species of *Caryedon*.

Size moderate : Length male. : 3.80 mm.

Host Plant : *Bauhinia* sp.

Specimens examined. **Holotype** 1 ♂, INDIA: GUJRAT : Okhaport, i. 1978 collected from pods of *Bauhinia* sp. (Fam. Leguminosae) **Paratype** 1 ♂ data as holotype.

Remarks: The present species *C. bauhinidus*, sp. nov. closely resembles a group of species, *C. crineus* Arora and *C. opacus*

Arora. It, however, differs in having ground colour of elytra pale yellowish and possessing five pairs of endophallic plates as compared to dark brown elytra and four pairs of endophallic plates in *C. crineus* Arora, and *C. opacus* Arora.

ACKNOWLEDGEMENTS

The author is highly indebted to Late Prof. G. L. ARORA, Department of Zoology, Panjab University, Chandigarh for his useful guidance during the course of investigations. Thanks are also due to the Head of Zoology Deptt., Panjab University, Chandigarh, India and PL 480 research grant programme, U. S. A. for providing facilities and financial aids respectively. My thanks are also due to Prof. H. R. PAJNI, Department of Zoology, Panjab University, Chandigarh for the help rendered during preparation of this manuscript.

REFERENCES

ARORA, G. L. (1977) Taxonomy of the Bruchidae (Coleoptera) of North West India. Part 1. Adults. *Oriental Ins.*, Suppl. **7**, 1–132.

BRIDWELL, J. C. (1929) A preliminary generic arrangement of the palm bruchids and allies (Coleoptera) with descriptions of new species. *Proc. ent. Soc. Wash.*, **31** (8), 141–160.

DECELLE, J. (1969) Le Parc National du Niokolo Koba, Fascicule III. XVII. Coleoptera - Bruchidae (Memories de L'institut Fonda mental D' Afrique noier. no. 84), I FAN DAKAR. 287–296.

DECELLE, J. (1973–1975) Coleoptera; Bruchidae de Ceylon. *Ent. scand.* Suppl., 4, 180–194.

DECELLE, J. (1975) *Les coleopteres Bruchidee d' Angola*. Publ. cult. Co. Diam. Ang., Lisboa 13–32.

SOUTHGATE, B. J. (1971) On the identity of *Caryedon pallidus* (Olivier) (Col., Bruchidae) and the description of two new *Caryedon* spp. *Bull. ent. Res.*, **60**, 409–414.

PAJNI, H. R. & TARLOK SINGH (1977) *Caryedon punjabensis* sp. nov. on *Cassia tora* (Coleoptera: Bruchidae). *Oriental Ins.*, **11** (2), 225–228.

PREVETT, P. F. (1965) The genus *Caryedon* in Northern Nigeria, with descriptions of six new species (Col. Bruchidae). *Ann. Soc. ent. Fr.* (*N. S.*) **1** (3) , 523–547.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 133 to 137

EFFECT OF BHC AND MALATHION ON THE TOTAL FREE AMINO ACID LEVEL IN THE HAEMOLYMPH AND FAT BODY OF THE LARVA OF RICE MOTH *CORCYRA CEPHALONICA* STAINTON (LEPIDOPTERA : PYRALIDE)

S. K. TIWARI & R. S. BHATT
Entomology Laboratory, Department of Zoology,
University of Gorakhpur, Gorakhpur, India 273 001

(*Received* 20 *July* 1988)

Present invesitigation deals with the changes caused by sublethal doses of BHC and malathion on the total free amino acid level of haemolymph and fat body of the larva of rice moth, *Corcyra cephalonica*.

(*Key words:* BHC, malathion, haemolymph, fat body, amino acid, *Corcyra cephalonica*)

INTRODUCTION

One of the most characteristic features of insect haemolymph is the high level of free amino acids (BUCK, 1953 ; FLORKIN, 1959; FLORKIN & JEUNIAUX, 1974; GILMOUR, 1961, 1965; WYATT, 1961; CHEN, 1962, 1966; CLEMENTS, 1963) whereas insect fat body is an active site for the intermediary metabolism of these amino acids (CHEN, 1966; KILBY, 1963). The high concentration of free amino acids is believed to play an important role in osmoregulation (BISHOP et al., 1926; BEADLE & SHAW, 1950), energy production for flight and cocoon construction (WYATT, 1961) and buffering of blood to some extent with a predominant function of units for protein synthesis (BUCK, 1953).

Insecticides have been shown to affect the level of free amino acids in various tissues including haemolymph and fat body of insects (WINTERINGHAM & HARRISON, 1956; MANSINGH, 1964, 1965; MOLCHANOV et al., 1980; SINGH, 1982). Such knowledge is essential to ascertain the effectiveness of chemical control measures against *C. cephalonica*. Hence as an objective of such programme the experiments were designed and conducted to investigate the effect of BHC and malathion on the total free amino acid level in haemolymph and fat body of the larva of *C. cephalonica*. The effect of these insecticides on the developmental stages of *C. cephalonica* has already been studied (TIWARI & BHATT 1987). The present investigation besides exposing the insecticidal influence on the larval biochemistry of this pest would also provide measures for its efficient chemical control.

MATERIAL AND METHODS

A rich standard culture of this insect was maintained in the laboratory on a normal dietary medium composed of coarsely ground jowar (*Sorghum vulgare*) mixed with 5% (w/w) powdered yeast inside large glass containers (150 mm diameter, 200 mm height) at 26 $\pm$ 1°C and 93 $\pm$ 5% R. H.

The insecticides, BHC 50% (w/w) W. P. containing gamma isomer 6.5% (w/w) and malathion 5% (w/w) W. P., used throughout this study were over 96% purity for the industrial standard goods. The normal dietary medium mixed with varying concentrations of these insecticides (0.001%, 0.002% and 0.003% of BHC) and (0.006%, 0.008% and 0.01% of malathion) was offered to the test insects as food.

From the above culture, whenever needed, newly emerged males and females were transferred to oviposition glass chambers (35 mm diameter, 200 mm height). Since *C. cephalonica* does not feed during their adult stage, no food was provided to them during their confinement in these vessels. Eggs laid by these females were collected and then placed in glass chambers (consisting of 250 ml beakers) for hatching.

Newly hatched larvae thus obtained were allowed to feed on a normal dietary medium (kept inside 250 ml beakers) exactly for 15 days. On the 16th day 50 larvae were transferred to each similar rearing chambers containing dietary medium mixed with above mentioned concentrations of BHC and malathion, and were allowed to feed for 10 days. Fifty larvae were laso kept as control with each set of experiments. Amount of insecticide consumed by larvae were calculated as μg/ larva on each dose levels of BHC and malthion.

On the completion of 25 days, the larvae from each experimental set were taken out separately from treated as well as control dietary media.

Haemolymph was obtained by making a small puncture by means of a sharp needle at the dorsolateral side of the prothoracic segment and drawing the blood, easily oozing out through this puncture, into a fine glass capillary tube.

Fat bodies were taken out from these larvae following careful dissections of these individuals performed on a clean glass slide containing some drops of distilled water under a stereosopic binocular microscope. The water and the flowed out haemolymph surrounding the fat body were completely drained off with the help of absorbent paper.

Estimation of total free amino acid was carried out according to the method of SPIES (1957) using glycine solution as standard.

Freshly separated tissues were homogennized in 96% ethanol, 10 mg/ml (w/v) in an electrical tissue homogenizer for 5 minutes and resulted homogenates were centrifuged for 20 minutes at 8000 g. The supernatants were subjected to total free amino acid estimation.

In order to develop colour, to 0.1 ml of supernatant, 0.1 ml of distilled water and 2. 0 ml of ninhydrin reagent were added and mixed thoroughly. These reaction mixtures were kept in boiling water bath for exactly 15 minutes. After cooling, 2.0 ml of 50% ethanol was added to each tube. A violet colour developed. The absorbancy was measured with the help of spectrophotometer, Systronics Digital Type 106 (MK II) at 575 nm against blank prepared in the similar way by using 0.1 ml of 96% ethanol instead of 0.1 ml of supernatant. The absorbancy was compared with a set of glycine solution (aqueous) of varying concentrations (10 μg/ml to 100 μg/ml). Each experiment was replicated at least six times. Appropriate calculations were made to compute the total free amino acid level. Results were expressed as μg free amino acid/mg tissues.

Statistical analysis was carried out following single classification analysis of variance to determine dose dependence and 't' test was applied to determine significant difference compared with controls as well as from the corresponding treated group.

RESULTS AND DISCUSSION

Both the insecticides (BHC and malathion) caused a dose dependent enhancement in the total free amino acid level in haemolymph

as well as in the fat body of the larva of rice moth *C. cephalonica* as represented in Table 1 and Figs. 1 and 2.

In case of control groups, the total free amino acid level was 87.880 ± 3.81 μg/mg and 11.408 ± 1.056 μg/mg in haemolymph and fat body respectively. The maximum enhancement in total free amino acid level in haemolymph (167% of control value)

TABLE 1. Changes in the total free amino acid level n haemolymph and fat body of the larva of rice-moth, *C. cephalonica* treated with BHC and malathion.

Dose (μg/larva)	Total free amino acid[1] (μg/mg) haemolymph	fat body
Control (untreated larvae)	87.880 ± 3.831 (100)	11.408 ± 1.056 (100)
BHC		
5	93.438 ± 3.028^{c} (106)	15.080 ± 0.936^{b} (132)
10	112.320 ± 2.273$^{aa'}$ (128)	17.258 ± 0.855$^{ac'}$ (151)
15	146.575 ± 2.010$^{aa'}$ (167)	19.500 ± 1.633$^{ac'}$ (171)
Malathion		
30	99.450 ± 3.625^{b} (113)	13.130 ± 1.213^{c} (115)
40	111.443 ± 3.112$^{ab'}$ (127)	16.120 ± 0.957^{a} (141)
50	134.355 ± 2.417$^{aa'}$ (153)	20.280 ± 1.414$^{ab'}$ (178)

[1] Values are expressed as the mean ± S. E. of six replicates; the values in parentheses indicate the percentage change, with control values taken as 100%.

a, b and c, significantly different ($P<0.001$),($P<0.005$) and ($P < 0.05$) respectively when compared with controls.

a', b' and c': Significantly different ($P<0.001$), ($P<0.005$) and ($P<0.05$) respectively when compared with corresponding treated group.

Analysis of variance showed that the response to the insecticide was dose dependent ($P< 0.001$).

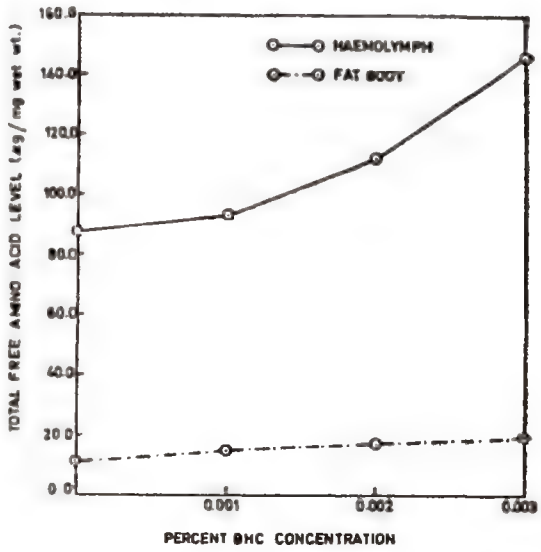


Fig. 1. Graphic representation of the effect of BHC on the total free amino acid level in the haemolymph and fat body of the larva of rice moth, *C. cephalonica*.

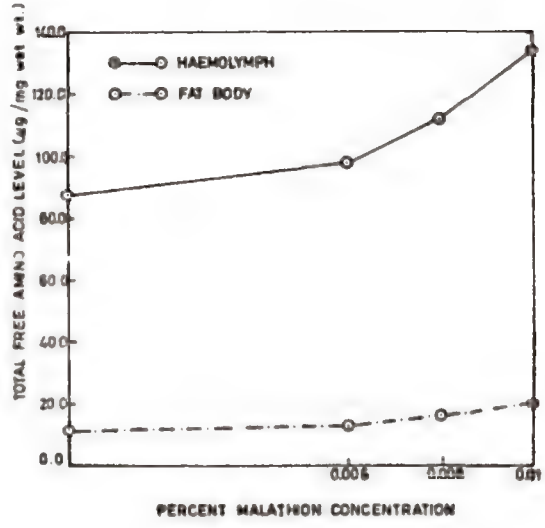


Fig. 2. Graphic representation of the effect of malathion on the total free amino acid level in haemolymph and fat body of the larva of rice moth, *C. cephalonica*.

and fat body (171% of control value) was observed in larvae treated with 15 μg/larva of BHC. Total free amino acid levels in haemolymph were increased to 106%, 128% and 167% of the controls while these levels in fat body were increased to 132%, 151% and 171% of controls following treatment with 5, 10 and 15 μg/larva of BHC respectively (Fig. 1).

In a similar way, the maximum enhancement in total free amino acid level in haemolymph (153% of control value) and fat body (178% of control value) was observed in larvae treated with 50 μg/larva of malathion. Total free amino acid levels in haemolymph were increased to 113%, 127% and 153% of the controls while these levels in fat body were increased to 115%, 141% and 178% of the controls following treatment with 30, 40 and 50 μg/larva of malathion respectively (Fig. 2).

Contrary to the present finding, malation casued a marked dose dependent decline in the free amino acid concentrations in the haemolymph of *Dysdercus koenigii* (SINGH, 1982) and *Blattella germanica* (MANSINGH, 1965). Similarly in DDT poisoned cockroaches, amino acid concentrations in haemolymph varied inversely with increase in toxicity (CORRIGAN & KEARNS, 1963).

AGOSIN et al. (1965) reported that in *Triatoma infestans*, higher DDT concentrations inhibited amino acid incorporation into protein causing adverse effect on protein biosynthesis. TIWARI & BHATT (1987, 1988) observed a dose dependent reduction in the total protein and glycogen levels in haemolymph and fat body of BHC and malathion treated larva of this pest. Thus, it may be concluded that in the present investigation, a rise in the total free amino acid level in haemolymph and fat body is plausibly on account of protein depletion and/or inhibition of amino acid incorporation into proteins.

The biochemical constituents of various tissues of srurviving larvae are regarded as one of the likely criteria permitting an assessment of the effectiveness of chemical control measures against pest population (MOLCHANOVE et al., 1980). Hence, the changes induced by sublethal doses of BHC and malathion on the total free amino acid level may be evaluated in the light of effectiveness of chemical control measures of insects in general and *C. cephalonica* in particular.

ACKNOWLEDGEMENT

The authors express their deep sense of gratitude to Dr. S. S. KRISHNA, Reader, Department of Zoology, University of Gorakhpur, Gorakhpur for making valuable suggestions in improving the manuscript.

REFERENCES

AGOSIN, M., L. ARAVENA & A. NEGHME (1965) Enhanced protein synthesis in *Triatoma infestans* treated with DDT. *Experimental Parasitology*, **16**, 318–324.

BEADLE L. & J. SHAW (1950) The retention of salt and the regulation of the NPN fraction in the blood of the aquatic larva *Sialia lutaria*. *J. exp. Biol.*, **127**, 96–109.

BISHOP, G. H., A. P. BRIGGS & E. RONZONI (1926) Body fluids of the honeybee larva. *J. biol. Chem.*, **66**, 77–88.

BUCK, J. B. (1953) The internal environment in regulation and metamorphosis, *in: Iusect Physiology* (ed. K. D. ROEDER) Wiley, New York, 191–217.

CHEN, P. S. (1962) Free amino acids in insects, 115–138, *in: Amino Acid Pool.* (ed. J. T. HOLDEN) Elsevier, Amsterdam.

CHEN, P. S. (1966) Amino acid and protein metabolism in insect development. *Adv. Insect Physiol.*, **3**, 53–132.

CLEMENTS, A.M. (1963) *The Physiology of Mosquitoes.* Pergamon Press, Oxford.

CORRIGAN, J. J. & C. W. KEARNS (1965) Amino acid metabolism in DDT poisoned American cockroaches. *J. Insect Physiol.*, **9**, 1–12.

FLORKIN, M. (1959) The free amino acids of insect haemolymph, 63–77, *in: Biochemistry of Insects.* (ed. L. LEVENBOK) Pergamon Press, London.

FLORKIN, M. & C. JEUNIAUX (1974) Haemolymph Composition, *in: Physiology of Insects.* (ed M. ROCKSTEIN) Academic Press, New York, **5**, 255–307.

GILMOUR, D. (1961) *The Biochemistry of Insects.* Academic Press, New York, 235–390.

GILMOUR, D. (1965) *The Metabolism of Insects.* Oliver & Boyd. Edingburg, 115–147.

KILBY, B. A. (1963) The Biochemistry of the Insect Fat body, 111–174, *in:* Advances *in Insect Physiology*, Vol. 1. Academic Press, London & New York.

MANSINGH, A. (1964) The free amino acids of the haemolymph of malathion resistant *Blattella germanica* L. *Indian J. Ent.*, **26**, 247–251.

MANSINGH, A. (1964) The effect of malathion on the metabolism of amino acids in the German cockroach *Blattella germanica. J. Insect Physiol.*, **11**, 1389–1400.

MOLCHANOV, M. L., F. S. KUTEEV, V. A. MOLCHANOVA & V. A. NIKIFOROV (1980) The influence of organophosphorus insecticides on proteins in the haemolymph of gypsymoth caterpillars. *Appl. Biochem. Microbiol.* (*Engl. transl. Prikl. Biochim. Microbiol.*, **16** (5) 548–554.

SINGH, R. (1982) Effect of malathion on the free amino acids in the haemolymph of *Dysdercus koenigii* (Hemiptera: Pyrrhocoridae). *Entomon*, **7** (3), 253–256.

SPIES, J.R. (1957) Colorimetric procedures for amino acids. *Methods in Enzymology* (ed. S. P. COLOWICK and N. O. KAPLAN) Academic Press, New York. 464–471.

TIWARI, S. K. & R. S. BHATT (1987) Effect of BHC and malathion on the developmental stages of the rice moth *Corcyra cephalonica* Stainton (Lepidoptera : Pyralidae). *Z. Angew.* Zool., **74**, 83–89.

TIWARI, S. K. & R.S. BHATT (1987) The influence of BHC and malathion on the total protein level in the haemolymph and fat body of the larva of rice moth *Corcyra cephalonica* Stainton (*Lepidoptera : Pyralidae*). Communicated.

TIWARI, S. K. & R. S. BHATT (1988) BHC and malathion induced changes in glycogen level in haemolymph and fat body of the larva of rice moth, *Corcyra cephalonica* Stainton (*Lepidoptera : Pyralidae*). *J. Adv. Zool.*, **9** (1), 25–29.

WINTERINGHAM, F. P. W. & A. HARRISON (1987) Study of anticholinesterase action in insects by a labelled pool technique. *Nature*, **178**, 81–82.

WYATT, G. R. (1961) The biochemistry of insect haemolymph. *A. Rev. Ent.*, **6**, 72–102.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 139 to 142

LIFE HISTORY AND SEASONAL ABUNDANCE OF *APANTELES ARISTAEUS*, A LARVAL PARASITOID OF *CYDIA LEUCOSTOMA*, THE FLUSHWORM OF TEA

N. MURALEEDHARAN & R. SELVASUNDARAM
UPASI Tea Research Institute, Nirar Dam B. P. O., Valparai, Coimbatore, India 642 127

(*Received* 20 *July* 1988)

The braconid parasitoid, *Apanteles aristaeus* Nixon is an important natural enemy of *Cydia leucostoma*, a pest of tea in South India. The parasitoid preferred late instar caterpillars for oviposition and in the laboratory, development was completed in 21.36 days. The three years' field study (1985-1987) showed that the maximum percentage of parasitism achieved by *A. aristaeus* was 17.64. A positive significant correlation was obtained between larval density of *C. leucostoma* and percentage parasitism.

(*Key words:* *Apanteles aristaeus*, *Cydia leucostoma*, parasitoid, tea pest)

The flushworm, *Cydia leucostoma* Meyrick (Tortricidae : Lepidoptera) is an important pest of tea and its incidence is more common in fields recovering from pruning. Populations of this leaf folding caterpillar are to a very large extent suppressed by the removal of infested shoots during 'plucking' (harvesting). Recent studies have shown that the endoparasitoid, *Apanteles aristaeus* Nixon (Braconidae: Hymenoptera) is an important natural enemy of this caterpillar in all the tea growing regions of South India (MURALEEDHARAN *et al.*, 1988). However, there is no information available on the biology or ecology of this braconid. In the present paper, we report the results of our studies on the life history and seasonal abundance of *A. aristaeus* in the Anamallais (Coimbatore District).

Field collected, parasitised larvae of *C. leucostoma* were reared in the laboratory to obtain adult parasitoids. Freshly emerged adults of *A. aristaeus* were caged in cylindrical glass containers (15 × 20 cm) and their mouths covered with fine cloth. Tea flowers, brushed with 20% honey solution, were placed in the container to provide food for the adult parasitoids. A piece of filter paper was also placed inside the cage and moistened periodically to provide sufficient humidity. Mated females were separated and released into smaller transparent plastic containers (7.5 × 6.5 cm). Flushworms of known age were provided for oviposition and those parasitised were removed daily and maintained separately. The host larvae were supplied fresh tea shoots. Observations were made at room temperature of 25–30°C and R.H. 75–90%.

Field studies were carried out from January 1985 to December 1987 to determine the intensity of natural parasitism by *A. aristaeus*. Six experimental blocks, each consisting of 200 bushes, were laid out in the farm attached to the Tea Research Institute and the bushes were kept free from insecticide application, since pruning. Assessments on the incidence of parasitism were made twice in a month, on the 5th and 20th, by collecting all the flushworm infested shoots from 10 bushes, selected at random from each block and examining individual flushworms.

Adults of *A. aristaeus* are 3–4 mm long, black with hind tibiae deep reddish yellow.

TABLE 1. Life history of *Apanteles aristaeaus* Nixon.

Details of observation	Duration (in days)		Mean ± SE
	Minimum	Maximum	
1. Incubation & larval period	8	13	10.12 ± 1.53
2. Pre- pupal period	1	2	1.62 ± 0.48
3. Pupal period	9	11	9.62 ± 0.69
4. Adult longevity (female)	2	15	6.20 ± 1.30
Adult longevity (male)	2	8	4.33 ± 0.65
5. Pre-oviposition period	1	2	1.50 ± 0.50

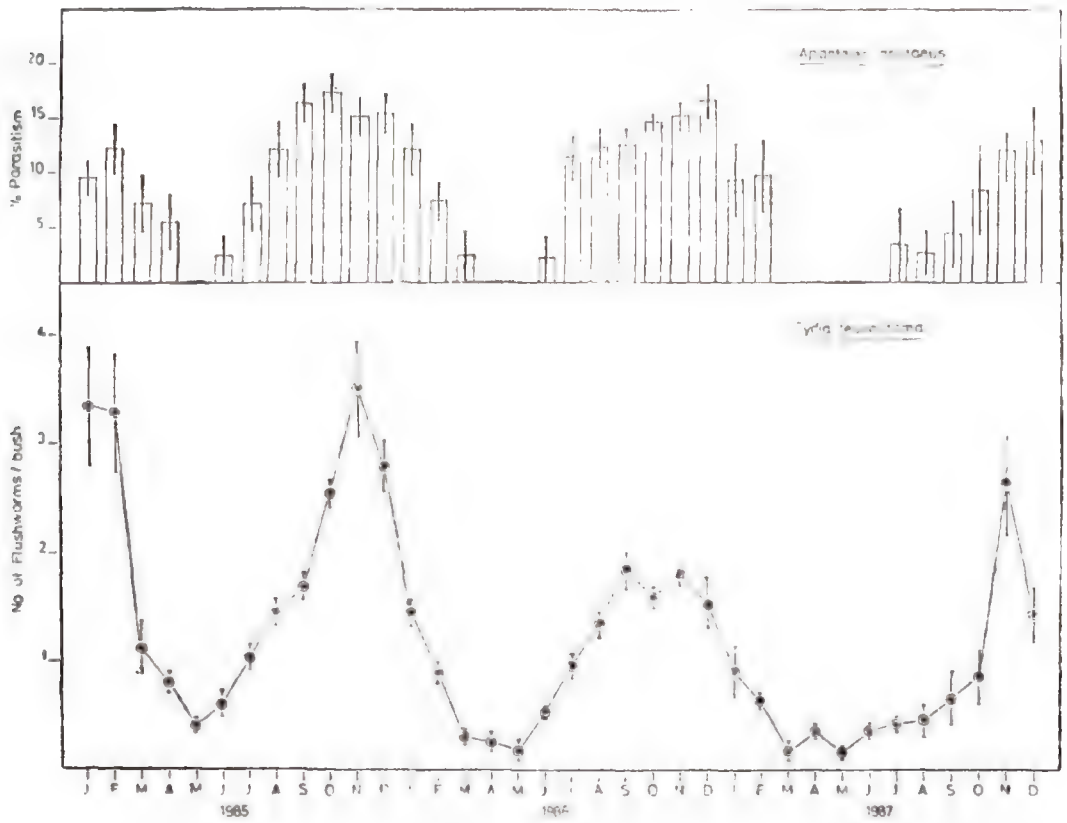


Fig. 1. Population trends of *Cydia leucostoma* Meyrick and percentage parasitism by *Apanteles aristaeus* in the experimental blocks (mean of six replications) during 1985–1987.

Soon after emergence they search for mates and mating occurred mostly in the morning hours. Copulation lasted for 30 to 50 seconds. Females oviposited 36 to 48 hours after mating. Third instar larvae of *C. leucostoma* were preferred for oviposition and a single female laid 2–4 eggs in the same larva. In all cases, only one larva of the parasitoid emerged out successfully and pupated. In the laboratory, one female could oviposit only a maximum of 3 flushworms. Duration of developmental stages, adult longevity and pre-oviposition period of *A. aristaeus* are given in Table 1. Longevity of males varied from 2–8 days, while females had a life span of 2–15 days. Male to female ratio was 1:1.

Figure 1 shows the population trends of flushworms and percentage parasitism by *A. aristaeus* in the experimental areas from 1985 through 1987. In all the three years high incidence of flushworms was noticed during September to December and the peaks in parasitism occurred after flushworm populations reached high levels. The mean maximum of percentage parasitism observed in all the experimental blocks was 17.64 in 1985. In 1986 and 1987, the percentage dropped to 16.65 and 13.0, respectively. However, during 1987 in certain experimental blocks incidence of parasitism had reached as high as 23.53%. To evaluate the efficiency of *A. aristaeus* in the experimental blocks, linear correlation coefficient and regression line were calculated. A positive significant correlation ($r = 0.52$, $P \leq 0.001$) was obtained between the population density of flushworms on tea bushes and percentage parasitism by *A. aristaeus* (Fig. 2).

A. aristaeus is known only from India and Indonesia and *C. leucostoma*, the flushworm of tea has been recorded as the host in both the countries. It appears that

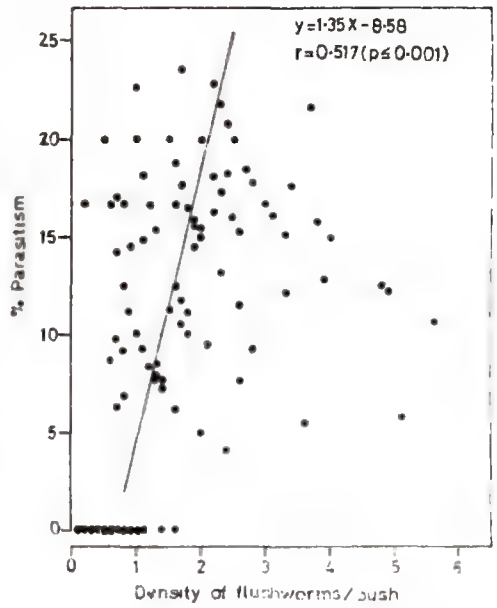


Fig. 2. Linear regression line of percentage parasitism by *Apanteles aristaeus* on the population density of flushworms.

this braconid is host-specific. The parasitoid always preferred third and later instar flushworms for oviposition. This goes contrary to the observations made on other important species of *Apanteles* such as *A. ruficrus* and *A. glomeratus* which preferred earlier instar caterpillar for egg laying (TAGAWA et al., 1982; KARNAVAR, 1983). The mean developmental period of the parasitoid within the host body was 10.12 days while the larval period of *G. leucostoma* from III instar to V instar varied from 12–18 days.

The rate of parasitism observed in our larval collections, is probably underestimated when compared to the real parasitization rate in the field. Since the flushworm infested shoots are collected at random and reared separately, these caterpillars are not exposed to further parasitization, wheras those remaining in the field would have been subjected to the attack of parasitoids for a longer period. Thus the data

presented here on the rate of parasitization may be lower than the acutal percentage parasitism in the field. In South India, the two other tea leaf folding caterpillars *Caloptillia theivora* (Walsingham) Gracillariidae) and *Homona caffearia* Nietner (Tortricidae), commonly found in pruned fields are efficiently controlled by a few indigenous parasitoids (SELVASUNDARAM & MURALEEDHARAN, 1987, 1988). Compared to these, the natural control of flushworms achieved by *A. aristaeus* is rather low.

ACKNOWLEDGEMENTS

The authors are thankful to Dr. Z. BOUCEK, CAB International Institute of Entomology, London for identifying the braconid and to Dr. S. NATESAN of our Institute for useful discussions. Financial support from the Council of Scientific and Industrial Research, New Delhi for this work is gratefully acknowledged.

REFERENCES

KARNAVAR, G. K. (1983) STUDIES on the population control of *Pieris brassicae* L. by *Apanteles glomeratus* L. *Insect Sci. Applic.*, **4** (4), 397–399.

MURALEEDHARAN, N., R. SELVASUNDARAM & B. RADHAKRISHNAN (1988) Natural enemies of certain tea pests occurring in southern India. *Insect Sci. Applic.*, (in Press).

SELVASUNDARAM, R. & N. MURALEEDAHRAN (1987) Life history and seasonal abundance of *Sympiesis dolichogaster* Ashmead (Insecta - Hymenoptera - Eulophidae) a larval parasitoid of the tea leaf roller. *Proc. Ist National Seminar on Entomophagous Insects and other Arthropods and their Potential in Biological Control, Advances in biological Control Research in India* (eds. JOSEPH, K. J. & U. C ABDURAHIMAN) Calicut, 106–109.

SELVASUNDARAM, R. & N. MURALEEDHARAN (1988) Observations on the larval parasitoids of *Homona coffearia* Nietner (Tortricidae : Lepidoptera) in a tea field at the Anamallais. *J. Plant Crops* (in Press).

TAGAWA, J., Y. SATO & T. TANAKA (1982) Developmental interactions between the armyworm *Leucania separata* (Lepidoptera : Noctuidae) and its parasite, *Apanteles ruficrus* (Hymenoptera : Braconidae). *Entomophaga*, **27** (4), 447–454.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 143 to 146

INVESTIGATIONS ON THE OCCURRENCE OF NATURAL ENEMIES OF SAN JOSE SCALE, *QUADRASPIDIOTUS PERNICIOSUS* COMSTOCK (HEMIPTERA: COCCIDAE) IN JUMMU & KASHMIR AND HIMACHAL PRADESH

J. N. THAKUR, U. S. RAWAT[1] & A. D. PAWAR[2]
Central Biological Control Field Laboratory, Lugaribhuthi, Seobag Kullu, (H. P.), India 175101

(*Received* 4 *September* 1988)

Extensive field surveys revealed that four species of parasitoids, viz., *Aphytis* sp. *proclia* group *proclia* Walker, *Azotus* ? *perspeciosus* Girault, *Encarsia perniciosi* Tower and *Teleterebratus? perversus* Compere & Zinna and four species of predtors, viz., *Chilocorus bijugus* Mulsant, *Coccinella septumpunctata* L., *Pharoscymnus flexibilis* Mulsant and *Sticholotis* sp.? *marginalis* Kapur are among the natural enemies of San Jose scale working well in J&K, while in Himachal Pradesh only one species of parasitoid viz., *Aphytis* sp. *proclia* group and three predators viz., *C. bijugus*, *C. septumpunctata* and *P. flexibilis* were reported feeding on San Jose scale. It is of particular interest to note that out of four parasitoids, two parasitoids, viz., *A. perspeciosus* and *T. ? perversus* have been reported for the first time in India. Field survey also revealed that four species of exotic predatory beetles, viz., *Chilocorus kuwanae* Silv., *Cybocephalus gibbulus* Frickson, *Lindorus lophanthae* Blasid and *Sticholotis medagassa* Weise released previously in J & K and H. P. by Commonwealth Institute of Biological Control, Indian Station, Bangalore and Central Biological Control Station, Srinagar (J & K) are absent in the field showing their non-establishment.

(*Key words:* natural enemies, parasitoids, predators, environmental factors, insecticides, economic threshold)

INTRODUCTION

San Jose scale, *Quadraspidiotus perniciosus* Comstock, a serious pest of temperate fruits, is world-wide in distribution practically occurring throughout the deciduous fruit growing areas of the world. This pest was found attacking nearly 200 different species of fruits, shrubs and ornamental plants belonging to 26 families (PRUTHI & RAO, 1951). In India, the pest is believed to have entered in J. & K. State along with some flowering plants like *Cydonia japonica* Lindl. which had been imported to decorate gardens at Srinagar, but its serious attack was observed in 1922. Now it has been recorded in all the states where deciduous fruit plants are grown and has become a serious problem to the growers. Because of its mode of living under waxy coverings, developments of resistance to commonly used insecticides, high costs and hazardous effects of insecticides, insecticidal control of this pest could not gain much appreciation and necessitated the use of biological control agents. From time to time considerable information regarding the occurrence of natural enemies of this pest was furnished by different workers. A detailed list of bioagents along with their places of origin has been reviewed by TUHAN *et al.* (1979). Some of these bioagents were imported by the Commonwealth Institute of Biological Control, Indian Station, Bangalore, in late fifties and were subsequently released in

[1]Assistant Director (Entomology), Central Biological Control Station, Solan 173212 (H.P.).

[2]Joint Director (Entomology), Directorate of Plant Protection, Quarantine and Storage, N. H. IV, Faridabad 121 001 (Haryana).

J & K, Himachal Pradesh and Utter Pradesh (TUHAN *et al.*, 1979). The released bioagents included *Encarsia perniciosi* Tower, *Aphytis diaspidis* Howard, *Chilocorus kuwanae* Silv. and *Cybocephalus gibbulus* Frickson. Later on recovery tests carried out by JOLLY (1961–1962) reported well establishment of *E. perniciosi* and *A. diaspidis* causing 86.5–89% parasitism in Himachal Pradesh. However, *A. diaspidis* was reported only in a few cases in Kashmir (TUHAN *et al.*, 1979). According to TUHAN *et al.* (1979) predatory beetles, viz. *Sticholotis medagassa* Weise and *Lindorus lophanthae* Blasid were released at Srinagar, but so far no recovery has been made in the field. This communication describes the latest position of natural enemy complex of San Jose scale in J & K and H. P. which are the leading apple producing States in India.

MATERIALS AND METHODS

With a view to know the existence and effectiveness of previously released exotic and indigenous bioagents in J & K and H.P., an extensive and intensive survey was conducted during the year 1982–1986. In J&K survey was conducted during September and October, 1982 and again during July 1986. The places surveyed included Khanabal, Kulgam, Shopian, Tral. Pampore, Lalnagar, Anantnag, Narval, Pattan, Sangrama, Sopore, Baramula, Tungmarg, Bandipore, Buchpore, Chattergam, Kandipore, Badgam, Kralpore etc. In district Lahaul and Spiti (H. P.) survey was conducted during August and September 1983 and places surveyed included Jahlma, Kirting, Kumari, Thirot, Arat, Kukumsari, Udaypur, Trilokinath, Kishoba, Shansha, Hinsa, Chating etc. In districts Solan, Sirmur, Shimla and Kullu (H. P.) the surveys were conducted regularly once in a week throughout the years of 1982–1986. Places surveyed were Khaltyu, Kandhaghat, Oachghat Kumarhatti, Deothiand Chail in district Solan, Rajgharh, Yashwantnagar in district Sirmur, Mashobra and Thanadhar in district Shimla, Bhuntar, Jari, Manikarn, Bhuthi, Rujak, Bhumtir, Katrain, Manali and Nagar in disrict Kullu. At each place natural enemy of San Jose scale either feeding or parasitising were observed carefully in infested orchards. Available parasitoids or predators in any of their life stages (egg, larva, pupa and adult) were collected with the help of fine brush, foreceps and aspirator as the case may be and were put in specimen tubes provided with artificial diet (SHING, 1982). Also scale infested twigs from each place were collected. The cut ends of infested twigs were dipped in melted wax to prevent further loss of cell sap through evaporation. The collected material was brought to the laboratory and immature stages were reared under controlled condition of temperature ($25 \pm 2°C$) and relative humidity ($70 \pm 10\%$) to obtain adults. Sets of infested twigs were caged in plastic jars. The open ends of jars were covered with the pieces of muslin cloth and fastened with rubber bands. The observations were made on the emergence of parasitoids or predators. The adults obtained were killed in an atmosphere of ethyl acetate. The parasitoids and predators collected in this way were sent for identification to Commonwealth Institute of Entomology, British Museum Natural History, London.

RESULTS AND DISCUSSION

Natural enemies of San Jose scale recorded during investigation are given in Table 1. All the recorded four species of parasitoids are present in J & K. The two sp., viz., *Azotus* ? *perspeciosus* and *Teleterebratus* ? *perverusus* have been reported for the first time in India. Besides these parasitoids AMIN & TRALI (1987) have reported two other parsitoids of San Jose scale i.e., *Azyptus kashmirensis* Narayanan and *Marietta carnesi* Howard from Kashmir

valley which were not recorded during the present study. In J & K *A.* sp. *proclia* group and *E. perniciosi* are most prevalent and sufficient in number contributing jointly 90–95% parasitism, while *A. ? perspeciosus* and *T. ? perversus* are rarely occurring and hardly contribute to 5–10% parasitism jointly. In H. P., it is interesting to note that in spite of well establishment of *A. diaspidis* and *E. perniciosi* (JOLLY, 1961–1962), both the species were found absent in the present survey. However *A.* sp. *proclia* group was observed in a few cases at Bhuthi and Katrain (district Kullu, H. P.). The extermination of these two species of parasitoids might be either due to continuous pesticidal spray or some other adverse agroclimatic or environmental factors unknown to the investigators.

Among the predators, all the four species are present in J & K. However, exotic predatory beetles, viz., *Chilocorus kuwanae, Cybocephalus gibbulus, Lindorus lophanthae* and *Sticholotis medagassa* released previously by C. I. B. C., Indian Station, Bangalore and C. B. C. S., Srinagar were not recorded at all showing their non-establishment. Also *Jauravia* sp. and *Chilocorus tristis* Pald. which have been reported as chief coccinellid predators of San Jose scale (PRUTHI & RAO, 1951) in Kashmir valley were not observed. In H. P., *C. bijugus, P. flexibilis* and *C. Septumpunctata* were recorded at some localities, while *S. ? marginalis* was completely absent. In district Lahual-Spiti (H. P.) neither parasitoids nor predators were observed in the field although the pest was present at many places. Non-existence of natural enemies in Lahual-Spiti might be due to cold weather prevailing for the most of the seasons. Indigenous species of predatory beetles, viz., *P. flexibilis* and *S. ? marginalis* which are the native of Kashmir (HERTING & SIMMONDS, 1971) were found in abundance on the infested trees in J & K. But, both these predatory beetles have low feeding capacity and were found not coping effectively with the rapidly increasing population of San Jose scale, while *C. bijugus* was found effectively controlling the population build up of San Jose scale consuming averagely 217 scales per beetle per day (PRUTHI & RAO, 1951). However, at many places grubs of *C. bijugus* were found attacked by a eulophid parasite i. e., *Aprostocetus neglectus* Domenichini (new record, identified from CIE, London) hampering its population build-up in nature to some extent. *C. septumpunctata* was found feeding on scales at a few places, but generally preferred soft bodied aphid as its pray rather than scales. Similarly, RAHMAN (1947) and PRUTHI & RAO (1951) reported the feeding of *C. septumpunctata* on scale in Kurran valley (now in Pakistan) and Jammu and Udhampur respectively. Periods of activity and percentage of parasitism or predation of natural enemies of San Jose scale is depicted in Table 1, which varied year after year depending upon the environmental factors including weather conditions prevailing in the region. Presence of all the natural enemies in J & K might be attributed to comparatively less or non-spraying of pesticides. During the survey it was observed that in J & K neglected orchards are more as compared to negligible in H. P.

From the foregoing investigations, it is concluded that insecticides have adverse effects on the natural enemy complex. An effective biological control of insect pests could be achieved if the insecticidal spray is not done at the cost of natural enemies, but as a part of integrated programme when felt necessary (when population density of pests reaches above economic threshold). Hence mass breeding and subsequent releases of the above bioagents in the months of June to September can show a great promise in control of pest. Still our knowledge about

TABLE 1. Natural enemies of San Jose scale recorded during investigation.

Order	Family	Name of insect	Status	Place & State	Period of activity	Range of parasitism or No./ infested twig
Hymenoptera	Aphelinidae	*Aphytis* sp. *proclia* group? *proclia* Walker	Parasitoid	Throughout J & K, Bhuthi & Katrain(H.P.)	July to October	50–75%
—do—	—do—	*Encarsia perniciosi* Tower	—do—	Throughout J & K	—do—	45–65%
—do—	—do—	*Azotus? perspecious*	—do—	—do—	—do—	2–7%
—do—	Encyrtidae	*Teleterebratus ?perversus* Compere & Zinna	—do—	—do—	—do—	3–6%
Coleoptera	Coccinellidae	*Chilocorus bijugus* Muls.	Predator	Throughout J & K and at a few places in H.P.	June to October	3–10/twig
—do—	—do—	*Coccinella septumpunctata* L.	—do—	—do—	—do—	1–4/twig
—do—	—do—	*Pharoscymnus flexibilis* Muls.	—do—	—do—	July to September	10–20/twig
—do—	—do—	*Sticholotis ? marginalis* Kapur	—do—	Throughout J & K	July to October	7–12/twig

natural enemy complex of San Jose scale is meagre and needs more investigations to have a complete list.

ACKNOWLEDGEMENTS

The authors are thankful to Dr. R. L. RUJAK, Plant Protection Advisor to the Govt. of India for providing the necessary laboratory facilities and encouragement. We also express our sincere gratitude to DRS. J. S. NOYES, A. POLASZEK, Z. BOUCK and T. G. VAGIRANI for their efforts in identification of insects.

REFERENCES

AMIN, M. M. & A. R. TRALI (1987) Seasonal history and biological control of San Jose scale, *Quadraspidiotus perniciosus* (Comstock) (Diaspidae : Homoptera) on apple in Kashmir. *J. biol. Control*, **1**, 3–6.

HERTING, B & F. J. SIMMONDS (1971) A catalogue of parasites and predators of terrestrial arthropods. *Section A, Vol.* 4, 174. pp.

JOLLY, C. L. (1961–62) Biological control of San Jose scale in H. P. Retrospect and Prospect. *J. Himachal Horticulture*, **2 & 3**, 211–216.

PRUTHI, H. S. & V. P. RAO (1951) San Jose sacle in India. *Tech. Bull. Dte 'P. P. Q. & S. Faridabad, No.* **3**, 1–48.

RAHMAN, K. A. (1947) San Jose scale and other fruit pests of fruit trees, fresh and dry fruits in Punjab and North West Frontier Province (Manuscript). (Quoted from PRUTHI, H. S. & V. P. RAO, 1951).

SINGH, P. (1982) *Artificial Diet* for *Insects*, *Mites* and *Spiders*. pp. 594. IFI Plenum, New York.

TUHAN, N. C., A. D. PAWAR & M. PARRY (1979(Biological control of San Jose scale, *Quadraspidiotus perniciosus* (Comstok) Hemiptera: Diaspidae). *Plant Prot. Bull.*, **31**, 73–79.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 147 to 152

BIOLOGY AND BEHAVIOUR OF CHALYBION BENGALENSE (DAHLBOM) (HYMENOPTEA : SPHECIDAE)

V. V. SUDHEENDRAKUMAR[1] & T. C. NARENDRAN
Department of Zoology, University of Calicut, Calicut University P. O., India 673 635

Female *Chalybion bengalense* wasp utilizes vacated mud-nests of other mud wasps or pre-existing holes on various substratum for nesting. The prey consists of spiders. The spiders are caught and paralysed from the field and brought into the nest. A single egg is laid on the body of one of the spiders. Usually the second or third brought to the cell is selected for oviposition. The number of spiders provisioned in a cell varies between 8 to 42. After completing provisioning, the wasp closes the cell mouth with mud. Detailed information on mating, resting, food, longevity and sex-ratio are also presented in this paper.

(*Key words:* biology, behaviour, *Chalybion bengalense*, wasp)

INTRODUCTION

In spite of the abundance of sphecoid wasps in India, very little attention has been so far made to work out their biology and behaviour. Because of their predatory habit these wasps have an important role as natural biocontrol agents of agricultural and forestry pests. Their hosts include spiders and insects of various orders.

The present paper deals with various aspects of the biology and behaviour of *Chalybion bengalense* (Dahlbom) which is one of the common sphecid wasps of India. This species has not been extensively studied so far apart from the preliminary observations reported by JAYAKAR & SPURWAY (1963, 1965, 1967).

MATERIALS AND METHODS

All observations were made under natural conditions. In the study area wasps were commonly observed coming inside buildings in search of nesting places. These included vacated mud-nests of sceliphronid and eumenid wasps or tubular holes on walls, furniture etc. To facilitiate behavioural observations wasps could be attracted to the laboratory by placing several vacated mud-nests at different places. The descriptions given below are based on observations recorded during 1977–1979.

RESULTS

Nesting activities were exclusively carried out by the female wasp. Usually the wasps (Fig. 1) became active about 2–3 h after sunrise. The first step in this process was to locate a vacated mud-nest (Fig. 2) or pre-existing hole suitable for nesting. This was followed by hovering around the nest site several times and landing on the nest. While on the nest the wasp antennated its surface several times. Now and then she made short flights from the nest but returned back without much delay.

Before occupying a vacated mud-nest, the wasp used to clean it. This included widening of the emergence hole at the cell mouth, removal of the cocoon, meconium, pellets of uric acid and remains of provision which the previous occupant had left behind. After cleaning the nest cell, the wasp attended to any repairs needed on it due to small holes, cracks etc. For this she brought mud from

[1]Present address: Division of Entomology, Kerala Forest Research Institute, Peechi, Trichur, Kerala, India 680 653.

outside and applied on the cell wherever necessary.

Provisioning and oviposition:

The prey consisted of spiders inhabiting bushes and trees. They belonged to the families Lycosidae, Agriopidae, Tetragnathidae and Pholeidae. During each hunting trip the wasp brought only one spider to the nest. All the spiders brought were immobilised. The spider was held between its cephalothorax and abdomen by the wasp's mandibles. The wasp also used her forelegs as a support to hold the spider in position. After reaching the nest cell, she peeped into it and deposited the spider as far back in the cell as possible.

The number of spiders provisioned in a cell varied between 8–42 ($\bar{X}$ = 14.7 $\pm$ 1.6 : n = 100) and the fresh weight of the provision varied between 0.5 – 2.7 mg ($\bar{X}$ = 1.46 $\pm$ 0.05 : n = 100). Normally the time taken to complete provisioning of one cell was about 4–6 h. Under normal conditions provisioning could be completed before sunset. However, when the provisioning could not be completed before the end of the 'work day' it was resumed on the next day.

Oviposition took place during the early part of the provisioning. A single egg was laid in a cell. The egg was deposited on the body of the second or the third spider brought to the cell and very rarely on the fifth or sixth spider. Out of the 82 females observed 41 laid eggs on the second spider, 29 on the third spider, 7 on the fifth spider and 5 on the sixth spider.

The act of oviposition was rather simple. After arriving at the nest with the particular spider the wasp positioned herself near the cell entrance. Holding the spider with her mandibles, she bent her abdomen under her and extended its tip to the base of the abdomen of the spider. Then she released the egg and glued it to the anterolateral side of the abdomen of the spider (Fig. 3). The duration of the act of oviposition varied between 14–27 min. ($\bar{X}$ = 20.38 $\pm$ 2.02 : n = 50). After oviposition the wasp peeped into the cell and pushed the spider far behind.

The wasp laid only a single egg at each act of oviposition. As a rule she laid a single egg a day. Direct observation on ten females which utilised mud-nests having empty cells varying from 4 to 21, revealed that a female is capable of laying as many as 12 eggs during its life time (Table 1). However an accurate estimate of the fecundity could not be made as the wasps under observation stopped coming to the nest after laying a few eggs in spite of the availability of more vacant cells.

The cell entrance (Fig. 2) was closed with a cap after completion of provisioning. The cell cap (Figs. 2, 4) is a wall built at the cell entrance by laying successive loads of building material. Mud was the base material used in the construction of the cell cap. In addition to mud, lime or dung or both were used to strengthen the cell cap. Based on the materials used for construction, the cell caps can be classified into four types (Figs. 2, 4) (1) cell cap made of mud only; (2) cell cap made of mud and dung; (3) cell cap made of mud and lime; (4) cell cap made of mud, lime and dung or mud, dung and lime. In the above classification of the cell cap the materials are mentioned according to their sequence of use during the cap construction. Mud was usually brought from outside. Occasionally the wasp collected mud from the nest surface itself. Before collecting mud, the wasp used to drink water to serve two purposes; (1) to wet the dry ground prior

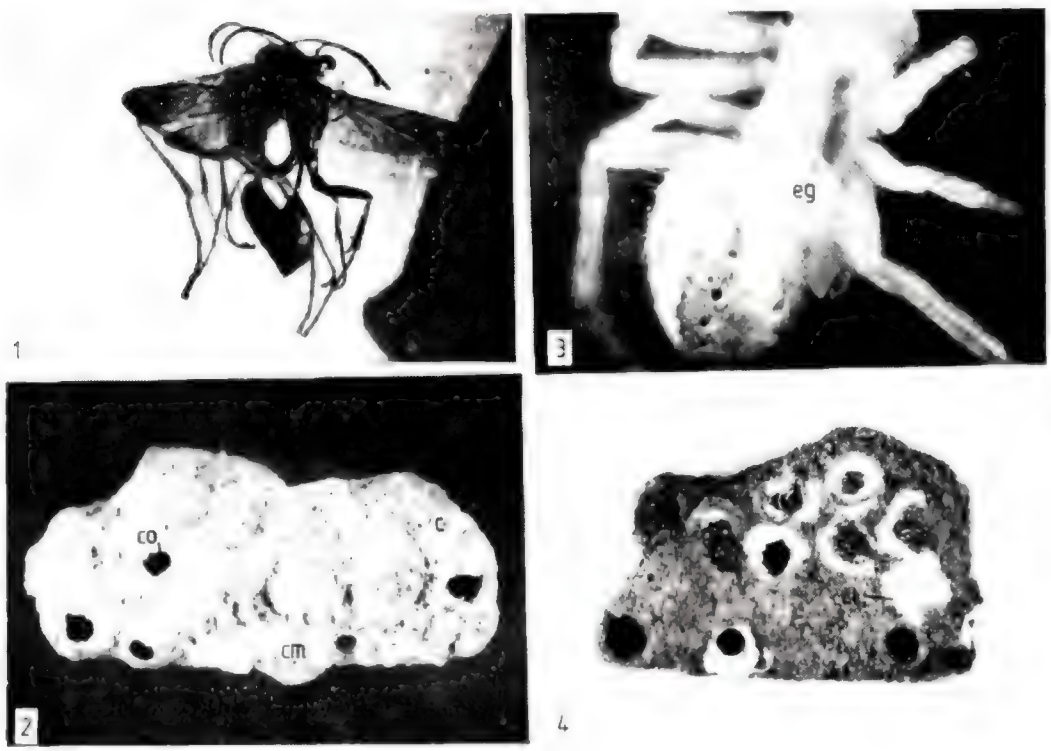


Fig. 1. Adult *C. bengalense*; Fig. 2. Dorsolateral view of a mud-nest of *Sceliphron coromandelicum* occupied by *C. bengalense* (C cell; Co Cell entrance; CM Cell cap made of mud); Fig. 3. Spider bearing egg of *C. bengalense* (eg egg); Fig. 4. Dorsal view of a mud-nest showing various types of cell caps. (Cd Cell cap made of mud, lime and dung; Cl Cell cap made of mud and lime).

TABLE 1. Fecundity of different *C. bengalense* wasps.

Serial number of the female	Period of egg laying	No. of cells in the mud nest used for nesting	No. of eggs laid	Fate of the wasp
1	15-5-1977 to 23 5 1977	12	9	X
2	6 4 1978 to 17 4 1978	15	12	X
3	15-5-1978 to 20 5 1978	6	6	
4	5 8 1978 to 13 8 1978	11	9	X
5	12-3-1979 to 15 3 1979	11	4	X
6	3 4 1979 to 9 4 1979	8	7	X
7	25 8 1979 to 27 8 1979	4	3	X
8	13 9 1979 to 19 9 1979	7	7	
9	17 10 1979 to 27 10 1979	21	11	X
10	13 12 1979 to 17 12 1979	8	5	X

Left the nest site after using all the cells.

X Discontinued nesting without making use of all cells.

to collection of mud; (2) to facilitate easy spreading of mud at the time of cell cap construction.

Prior to collection of mud the wasp first antennated the spot to be quarried for a few seconds. Then keeping the antennae sideways she regurgitated water on to the surface and repeatedly and rapidly sank her mandibles into it. While doing so, she turned her head around so as to cut out mud more or less in the form of a ball. The mud ball held in between the mandibles was then held pressed against the inner rim of the cell mouth. By closing and opening the mandibles and turning the head around, mud was spread around the cell mouth from its edge to the centre to form the cell cap.

As stated earlier the two other materials used for cell cap construction were lime and cowdung. Female wasps were generally observed collecting lime from lime-coated walls of buildings. Occasionally they collected uric acid droppings of birds to use instead of lime. The number of loads of building material used for constructing one cell cap varied between 9–33 ($\bar{X}$ = 18.5 : n = 46).

Temporary cell cap:

Temporary sealing of the cell was usually done when the wasp failed to complete provisioning before the end of the day. The building material was mud and very rarely lime was also incorporated. The number of loads of building material used, varied from 3 5. The temporary cell cap was usually removed on the next day to resume provisioning. The wasp removed the cell cap by regurgitating water on it and biting out pieces of mud.

Mating:

Mating activities were observed under laboratory condition. While males mated soon after their emergence, females showed a premating period of 7–8 h. Females were found mating only once during their life time. However, males mated with several virgin females. Females more than one week old were generally reluctant to mate. As a rule mating took place only during the day time.

Resting:

During the study period field observations were made on the resting behaviour of adult wasps. Adult aggregations were observed on hanging threads within buildings on leaves of *Chromolaena odorata*, and hanging branches of *Vernonia* plants. The sex-ratio count taken on two occasions suggests male predominance in such aggregations (Table 2). In all the above cases the individual wasps were present in the aggregation without much bodily contact with each other. Usually the wasps arrived at the resting site and formed aggregations before sunset. In the morning they left the site by 0800–0900 h.

TABLE 2. Sex ratio of sleeping aggregations of *C. bengalense*.

Substratum on which wasps aggregated	Total number of individuals in the aggregation	No. of males	No. of females
On hanging thread inside a building	10	06	04
On *C. odorata* plant	28	24	04

Food:

Adults were observed feeding on extra-floral nectaries of plants belonging to the families Umbelliferae, Compositae and Euphorbiaceae. Under laboratory conditions they fed on dilute honey.

Longevity:

Under laboratory condition life-span of honey fed females varied between 2–38 days with an average of 21 days (n = 100). Under similar conditions the life-span of 100 males varied between 2–35 days with an average of 14 days.

Sex-ratio:

Out of the 344 adults collected during 1977–1979, females were predominating, the sex-ratio between females and males being 4 : 1.

DISCUSSION

According to MUESEBECK *et al.* (1951) and EVANS (1963) *Chalybion californicum* wasps apart from using disused cells of *Sceliphron* spp. empty the contents of new cells recently sealed by the latter and use it. Similar behaviour has also been reported in the case of *C. japonicum* (IWATA, 1939). In contrast to these observations we have not observed a single instance of such behaviour in the case of *C. bengalense*.

Though *Chalybion* wasps deposit eggs on the abdomen of the spider (prey), there is disagreement among various workers as to when it is laid. While RAU (1928) claimed that *C. californicum* oviposited on the last provision, MUMA & JEFFERS (1945) reported that it was on the first provision. According to BORDAGE (1912) *C. bengalense* female laid egg on the last spider brought to the cell. Our observations show that in *C. bengalense* oviposition is taking place during the early stage of provisioning.

Temporary closing of the nest is a characteristic phenomenon associated with a number of sphecoid wasps (IWATA, 1976). JAYAKAR *et al.* (1965) remarked it as a variant behaviour. The present study has revealed that *C. bengalense* female usually performs this behaviour whenever she fails to complete provisioning before the end of the work day. This can be interpreted as a safety measure adopted by this species to protect the food material of a partly provisioned nest from the attack of natural enemies.

Night or evening aggregation (resting behaviour) have been reported in several groups of solitary aculeata including sphecoidea. RAU & RAU (1916) reported sleeping behaviour of *C. californicum*. As observed in the case of *C. bengalense*, resting aggregation of *C. californicum* also consisted of both sexes. ANDREWS (1969) interpreted this behaviour as concerned with mating. RAU & RAU (1916) ruled out such a possibility. Our observation tends to confirm the opinion of RAU & RAU, since no individual of a resting aggregation of *C. bengalense* attempted mating. EVANS & LINSELY (1960) suggested that such an aggregation may provide protection from predators. FREEMAN & JOHNSTON (1978) has described this as a pheromonal attraction.

REFERENCES

ANDREWS, C. (1969) *The Lives of Wasps and Bees.* The Trinity Perss. Worcestor and London 204 pp.

BORDAGE, E. (1912) Notes biologiques recueilies a l' Ile de la Re union. *Bull. Sci. France Belgique*, **46** (7), 1–64.

EVANS, H. E. & E. G. LINSLEY (1960) Notes on a sleeping aggregation of solitary bees and wasps. *Bull. Soc. Calif. Acad. Sci.*, **59**, 30–37.

FREEMAN, B. E. & B. JOHNSTON (1978) Gregarious roosting in the sphecid wasp *Sceliphron assimile*. *Ann. ent. Soc. Amer.*, **71** (3), 435–441.

IWATA, K. (1939) Habits of *Sceliphron (Chalybion) inflexum* Sickmann. *Mushi*, **12**, 92–101.

IWATA, K. (1976) *Evolution of Instinct: Comparative Ethology of Hymenoptera* (Translation from Japanese). Amerind Publishing Company, New Delhi, 535 pp.

JAYAKAR, S. D. & H. SPURWAY (1963) The use of vertebrate faeces by the sphecoid wasp *Chalybion bengalense* (Dahlb.). *J. Bombay Nat. Hist. Soc.*, **60**, 747–748.

JAYAKAR, S. D. & H. SPURWAY (1965) Variant behaviour of *Chalybion bengalense* (Dahlb). *J. Bombay nat. Hist. Soc.*, **62**, 169–172.

JAYAKAR, S. D. & H. SPURWAY (1967) The nesting activities of the vespoid potter wasp *Eumenes companiformis esuriens* (Fabr.) compared with the ecologically similar sphecoid *Sceliphron madraspatanam* (Fabr.) (Hymenoptera). *J. Bombay nat. Hist. Soc.*, **64**, 304–332.

MUESEBECK, C. F. W., K. V. KROMBIEN & H. K. TOWNES (1951) *Hymenoptera of America North of Mexico*. Synoptic Catalogue. U. S. Dept. Agric. Monograph, 1240 pp.

MUMA, M. H. & W. F. JEFFERS (1945) Studies of the spider prey of several mud dauber wasps. *Ann. ent. Soc. Amer.*, **38**, 245–255.

RAU, P. (1928) The nesting habits of the wasp *Chalybion caerulem*. *Ann. ent. Soc. Amer.*, **21**, 25–35

RAU P. & N. RAU (1916) The sleep of insects, an ecological study. *Ann. ent. Soc. Amer.*, **9**, 227–274.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 153 to 157

MULTIPLICITY OF β-GLUCURONIDASE DURING METAMORPHOSIS OF *TRIBOLIUM*

V. D. ARABALE
Department of Zoology, D. B. F. Dayanand College of Arts & Science, Solapur (Maharashtra), 413 002 India

(*Received* 4 *September* 1988)

Characterization of β – glucuronidase was carried out during the metamorphic events of the two species of *Tribolium*. The parameters like pH optima, thermal stability and effect of various modifiers on the enzyme activity were employed for the characterization studies. Partially purified samples from different stages of the two species exhibited two pH optima, double thermal decay, thus indicating dual nature i. e., lysosomal and microsomal. The empty puparia, however, exhibited single pH optimum and single thermal decay and indicated its lysosomal nature. The data obtained from the characterization studies was compared with the available literature and interpreted from the view point of physiological role during metamorphosis of insects.

(*Key words:* β – glucuronidase multiplicity, metamorphosis, *Tribolium*)

INTRODUCTION

The intracellular distribution of β-glucuronidase is unusual amongst the lysosomal enzymes, since substantial amounts of activity are present in lysomal and microsomal fractions. This has frequently been demonstrated by tissue fractionation studies (DE DUVE *et al.*, 1955; DEAN, 1974). Consistent histochemical reactions have also been obtained (FISHMAN *et al.*, 1967). Of the several lysosomal acid hydrolases, alterations in the acid phosphatase during metamorphosis of some insects have been shown by HEGDEKAR & SMALLMAN (1967), RUSSO CAIA (1967) and PANT & LACY (1969). A similar enhancement in the activity of β-glucuronidase was also reported by HEGDEKAR & SMALLMAN (1969) and by VARUTE & SAWANT (1971).

Based on the criteria such as pH optima, substrate specificity, effect of modifiers etc., multiple nature of β-glucuronidase has been reported, in many of the vertebrate organs (MILLS *et al.*, 1953; SMITH & MILLS, 1953; BARTALOS & GYORKEY, 1963; VARUTE, 1970; VARUTE & MORE, 1971). Among the insects there are, however, scanty reports regarding the heterogeneity of β-glucuronidase. The present paper, therefore, deals with some properties of β-glucuronidase with a view to find out its possible multiplicity during the metamorphic events of the two closely related species of *Tribolium*.

MATERIALS AND METHODS

The two species of *Tribolium* i.e., *T. castaneum* and *T. confusum* were selected for the study. Pure stock of these insects was reared separately in the laboratory under constant conditions of temperature and humidity. The fourth larval stage (full fed and full grown wandering stage), the mid-pupa and the full grown adults were selected for the study. Since the empty puparia contained an appreciable quantity of the enzyme, they were also utilised for the characterization studies.

The above stages were isolated from the culture medium and cleaned properly. The larvae and adults were immobilized by cold

treatment and were then utilized for the enzymatic studies. Enzyme characterization was carried out by employing the parameters of pH optima, thermal stability, effect of inhibitors/activators on partially purified samples of the above stages. For partial purification of β–glucuronidase, the method of BERNFELD *et al.* (1953) modified by VARUTE & MORE (1973) was employed. Biochemical assay of the enzyme was carried out according to the method of FISHMAN (1965, 1967) employing phenolphthalein mono-β-D-glucuronic acid (0.01M) as substrate.

The effect of pH on enzyme activity was determined in 0.1 M acetate buffers ranging from pH 3.6 to 5.6 while the effect of the following modifiers such as mucic acid (0.01 M), glucuronic acid (1 mM), mercuric chloride (0.005 M), cupric sulphate (0.1 M) and albumin (0.01 M) was also determined. The stock solutions of these were prepared in 0.1 M acetate buffer. The thermal activity of the enzyme was investigated at 65.5°C. The remaining activity was measured for 1–45 minutes in the aliquotes removed at an interval of 5 minutes. The log of percent remaining activity was plotted as a function of time (PRICE & FREIEDEN, 1963).

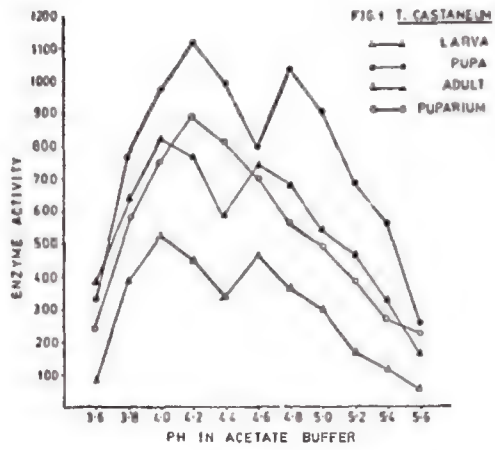
OBSERVATIONS

Effect of pH: The pH curves for the various stages including the empty puparia of *T. castaneum* and *T. confusum* are graphically illustrated, in Fig. 1 and Fig. 2 respectively. The pH optima varied from stage to stage. All the stages of the two species, except puparia, exhibited two pH optima curves. In general, the curves were slightly broader. In *T. castaneum* the enzyme from the larval extract showed the first peak at pH 4.0 and the second at 4.6. Similar peaks were evident in the adult. In case of the pupa, the first pH optimum curve was seen at pH 4.2 while the second at pH 4.8. The empty puparia, however, exhibited the single curve at optimum pH of 4.2.

The pattern of the pH optima in different stages of development of *T. confusum* were also similar to those of *T. castaneum*. However, the values for the two curves were different in that the larva had the first pH optimum at 4.2 and second one at 4.8. The corresponding peaks in the pupa and adult were seen at pH 4.0 and 4.6. The puparia exhibited the same pH optimum (4.2) as in was found in *T. castaneum*.

Effect of modifiers:

The percentage of inhibition and acti-



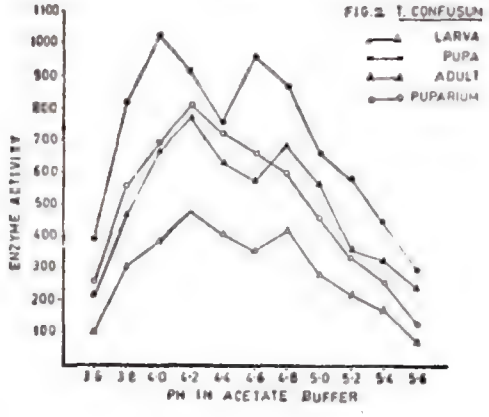


TABLE 1. Effect of modifiers on β-glucuronidase activity of *T. castaneum* and *T. confusum*. Values indicate percentage of inhibition/activation.

Stage of development	Mucic acid (0.01M)	Glucuronic acid (0.1 mM)	$HgCl_2$ (0..005 M)	$CuSO_4$ (0.1 M)	Albumin (0.01 M)
T. Castaneum					
Larva	59.2	13.2	78.01	87.2	17.2
Pupa	89.4	20.3	85.3	91.2	18.07
Adult	61.3	8.6	53.8	82.3	11.3
Puparia	69.1	26.1	76.2	85.2	27.5
T. confusum					
Larva	62.7	16.8	80.6	83.5	15.5
Pupa	96.2	16.7	98.2	91.5	17.2
Adult	68.5	14.2	57.03	79.1	14.5
Puparia	65.8	28.6	71.3	88.9	24.7

vation of the enzyme varied in different developmental stages. The values of it are given in Table 1. Of the various agents employed, mucic acid, glucuronic acid, $HgCl_2$ and $CuSo_4$ exhibited the inhibitory action on the enzyme while albumin activated it. Amongst the inhibitors, glucuronic acid showed least inhibition while $CuSO_4$ had a higher range of inhibitory capacity. The empty puparia of both the species exhibited an appreciable percentage of inhibition/activation.

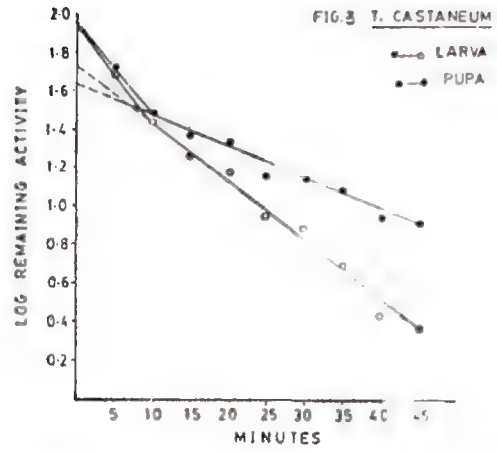
Thermal stability:

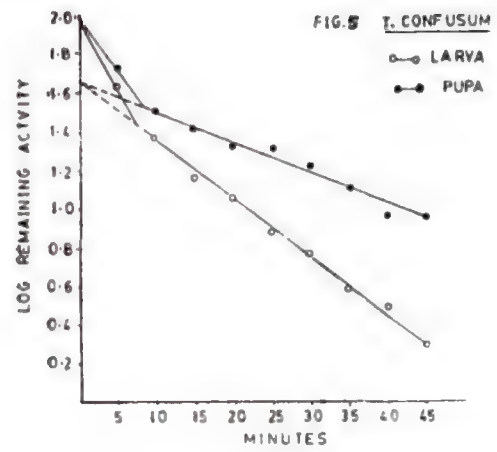
Effect of temperature on β-glucuronidase activity in different stages of both the species are graphically shown in Figs. 3, 4, 5 and 6. The anzyme was found to be heat-stable. Different stages exhibited two thermal decays while the puparia of both the species had a single decay. About 90–98% activity was lost after 45 minutes treatment.

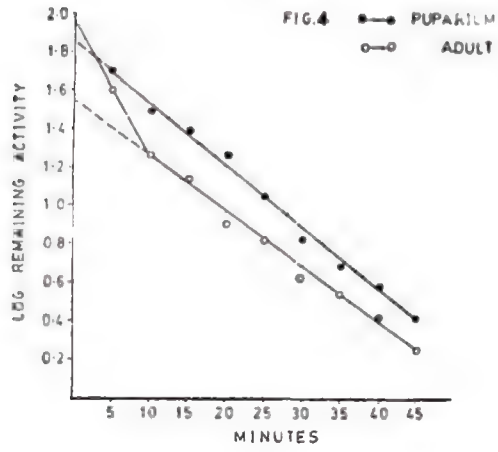
DISCUSSION

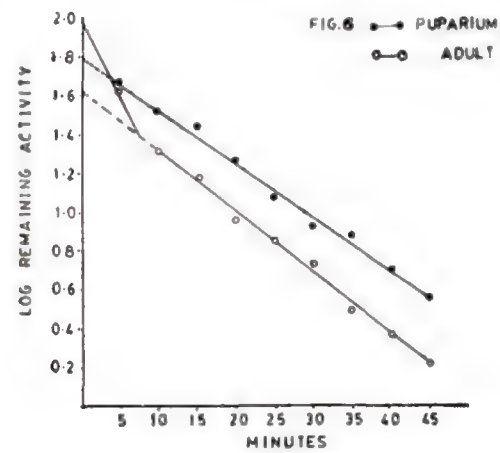
Characterization studies of β-glucuronidase during postembryonic development of the insects studied presently show interesting results. Invariably the enzyme from different sources exhibits double pH optima : one in the range of 4.0–4.2 and another in the range of 4.6–4.8. Such distinct differences in the pH optima kinetics indicate that the enzyme exists in two forms in the purified samples. Histochemical studies carried out during the present investigation also indicate its dual localization: a granular lysosomal and a nongranular diffused microsomal one. Such a dual nature of β-glucuronidase has been observed during insect metamorphosis by HEGDEKAR & SMALLMAN (1969), VARUTE & SAWANT (1971) and during anuran metamosphosis by VARUTE (1970).

The enzyme exhibiting an optimum pH in the range of 4.0–4.2 is lysosmal and the one with a pH range between 4.6–4.8 is microsomal. Many reports are available showing such double pH optima with more or less similar pH for both the lysosmal and microsomal fractions (MILLS *et al.*, 1953; SMITH & MILLS, 1953; BARTALOS & GYORKEY, 1963; VARUTE, 1970; GLASER &









CONRAD, 1980). These workers have tried to establish a correlation between the biochemical and cytochemical forms of β-glucuronidase.

The dual nature of β-glucuronidase is further substantiated by the thermal stability studies. The two thermal decays of the enzyme obtained from different sources indicate two components i.e., a heat-stable and heat-labile. Assuming that each decay, in fact, representing an individual type, indicates the occurrence of two types of enzymes or one enzyme with two active sites, each having a different sensitivity to heat inactivation. It seems that the distinct differences in enzyme kinetics and the cytologic localization, the first possibility is probable. According to BROF *et al.* (1978) the differences in enzyme kinetics could be due to an accessory activator protein and *in vivo*, β-glucuronidase is a peripheral membrane protein both in the lysosomes and microsomes. Solubilization of the enzyme has removed it from proteins and lipids with which it is intimately associated *in vivo*.

The enzyme present in the empty puparia shows distinct kinetic properties in that it has only one pH optimum and a single thermal decay (heat-stable). This indicates and confirms that puparial β-glucuronidase is lysosomal in nature. This further confirms, though indirectly, that the lysosomal

fraction has migrated, after completion of its mission, to the puparium where it is stored.

The data obtained for inhibitors/activators very small corraborates with the results obtained by VARUTE & SAWANT (1971) during insect metamorphosis and VARUTE (1970) and VARUTE & MORE (1971) during anuran metamosphosis. The lysosomal and microsomal fractions from both the groups of animals showed different range of pH optima, and also contain heat-stable and heat-labile components. Distinct differences in their response to inhibitors and activators indicate that though the enzyme in the anurans and insects functions during the metamorphic events, they might be in all probability are different proteins. Such identity of physiological role but differences in characters of the enzyme from two distinct groups of animals showing a common phenomenon of metamorphosis might be of value in the elucidation of evolutionary significance of the enzyme which still remains unattempted.

ACKNOWLEDGEMENTS

This paper is a part of the Ph. D. thesis. The author is thankful to Dr. N. K. MORE, Reader in Entomology, Shivaji University, Kolhapur for his valuable guidance and to University Grants Commission for the award of Teacher Fellowship.

REFERENCES

BARTALOS, M. & F. B. GYORKEY (1963) β-glucuronidase in mammary gland and lung cancer. *J. Am. Geriatric* Soc., **11**, 21–32.

BERNFELD, D. & J. S. NISSELBAUM & W. H. FISHMAN (1953) Purification of calf liver β-glucuronidase. *J. biol. Chem.*, **202**, 763–769.

DEAN, R. T. (1974) Rabbit β-glucuronidase. Purification and properties and the existence of multiple forms. *Biochem. J.*, **138**, 395–405.

DE DUVE, C., B. C. PRESSMAN, R. GIANETTO, R. WATTIAUX & F. APPELMANS (1955) Tissue fractionation studies. 6. Intracellular distribution patterns of enzymes in rat liver tissue. *Biochem. J.*, **60**, 604–617.

FISHMAN, W. H. (1965) Assay of β-glucuronidase, 869–874: *in* : *Methods of Enzymatic Analysis* (Ed. BERGMEYER), Academic Press, New York.

FISHMAN, W. H. (1967) Determination of β-glucuronidase, 77–105, *in: Methods of Biochemical Analysis*. Vol XVI.

FISHMAN, W. H., S. S. GOLDMAN & D. DELELLIS (1967) Dual localization of β-glucuronidase in the ER and in lysosomes. *Nature*, **213**, 457–460.

HEGDEKAR, B. M. & B. N. SMALLMAN (1967) Lysosomal acid phosphatase during metamorphosis of *M. domestica*. *Can. J. Biochem.*, **45**, 1202–1206.

HEGDEKAR, B. M. & B. N. SMALLMAN (1967) Intracelluair distribution of β-glucuronidase activity during metamorphosis of the house fly, *M. domestica*. *Can. J. Zool.*, **47**, 45–49.

MILLS, G. T., J. PAUL & E. E. B. SMITH (1953) β-glucurondiase. II. Preparation and properties of ox spleen β-glucuronidase fraction. *Biochem. J.*, **53**, 232–241.

PANT, R. & P. S. LACY (1969) Phosophatase activity in *P. ricini* during development. *Indian J. exp. Biol.*, **6**, 154–156.

PRICE, S. & E. FRIEDEN (1963) β-glucuronidase from amphibian tails. *Comp. Biochem. Physiol.*, **10**, 245–251.

RUSSO-CAIA, S. (1967) Histochemical study of acid-phosphatase during metamorphosis of *M. domestica*. *Atti. Acad. Naz. Lincei Rene cl. Sci. Fis. Mat. Nat.*, **43**, 129–134.

SMITH, E. E. B. & G. T. MILLS (1953) Studies of β-glucuronidase. IV. The purification and properties of ox liver β-glucuronidase. *Biochem. J.*, **54**, 164–172.

VARUTE, A. T. (1970) Multiplicity of β-glucuronidase in anuran tadpoles in metamorphosis. *Ind. J. exp. Biol.*, **8**, 92–95.

VARUTE, A. T. & V. A. SAWANT (1971) Multiplicity of β-glucuronidase in insect development and metamorphosis. *Ind. J. exp. Biol.*, **9**, 333–337.

VARUTE, A. T. & N. K. MORE (1973) Lysosomal acid hydrolases in the chloragogen cells of earthworms. *Comp. Biochem. Physiol.*, **45**, 607–635.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 159 to 164

FIELD PEST PROBLEMS OF MUNGBEAN *VIGNA RADIATA* IN SOUTHERN REGION OF SRI LANKA

ROHAN H. S. RAJAPAKSE & K. W. JAYASENA[1]
Department of Agronomy, University of Ruhuna, Mapalana, Kamburupitya, Sri Lanka

(*Received* 4 *October* 1988)

A field experiment was conducted at the Faculty of Agriculture, University of Ruhuna for the purpose of identification, distribution and evaluation of management tactics of insect pests of mungbean *Vigna radiata* in 1986 Maha October-January season.

The major pests were the beanfly *Ophiomyia* (*Melanagromyza*) *phaseoli* (Tryon.), *Maruca testulalis* Geyer, and *Bemesia tabaci* Genn. and the bug complex *Nezara* spp. and *Riptortus* spp. were minor pests. A weak positive correlation was found between *O. phaseoli* infestation and plant height. The mungbean selections 'VC 4281-B', 'VC 4221-B', 'VC 4290 B' and 'V 6083' showed less than 10% bean fly infestation under low and high nitrogen regime. Seed treatment with monocrotophos and Sevin, controlled *O. phaseoli* significantly for 4 weeks after planting. This protection afforded during this vulnerable stage gave the potential to use other pest management techniques effectively to control beanfly.

(*Key words:* *Vigna radiata*, pests, control)

Mungbean, *Vigna radiata* the most popular legume in Sri Lanka in early 1970's is now relegated to a secondary position because of pests and virus diseases (VIGNARAJAH, 1978). Mungbean is cultivated in about 31000 hectares in Sri Lanka with an average yield of 0.5 t/ha.

In Sri Lanka, more than 40 insect species are known to feed on grain legumes (SUBASINGHE & AMARASENA, 1983) and about 20 species have been found to attack mungbean in different stages of growth. There is no information available on field pests of mungbean in intermediate and dry regions of southern region of Sri Lanka. The following research was conceived to assess and investigate field pests of mungbean at the Faculty of Agriculture, University of Ruhuna, Mapalana, Kamburupitiya, Sri Lanka from Maha (October-December) 1986. The objectives of the study were to : 1. identify the major pests of mungbean; 2. screen 120 selections of mungbean for resistance under low fertility and high fertility conditions to the major pest *O. phaseoli*; and to 3. evaluate the effect of five insecticides used as seed treatment against *O. phaseoli* the major field pest of mungbean.

MATERIALS AND METHODS

Experiment 1 – *Identification of pests, varietal evaluation under two nitrogen regimes:*

One hundred and twenty mungbean selections from AVRDC, Taiwan with seven local checks were evaluated for their pest susceptibility / resistance under two nitrogen regimes at University of Ruhuna Farm, Mapalana, Kamburupitiya, Sri Lanka. Two experimental sites with similar (4 × 1.5 m) plot sizes were selected. The first site was fertilized prior to planting (high fertility) with NPK 112 kg N/ha, 112 kg K/ha, 56 kg P/ha and 2 weeks later urea was

[1]Regional Research Station, Department of Agriculture, Angunakolapelessa, Sri Lanka.

applied as top dressing at 112 kgN/ha. Each selection was planted in a 25 × 5 cm row plot. The second site was a sandy (low fertility) tract with low N and no fertilizers were applied. Two replicates of each selection were tested. The selections in both experimental sites were inoculated with *Rhizobium* mixture for *Vigna radiata* and *V. mungo* before planting the seeds. The sites were irrigated daily and no pesticides were applied during the test period. The selections planted in rows were examined every alternate day during early morning (8–9 AM) to determine insect damage and density.

Sampling for insect pests began 1 week after seed germination when the plants were about 10–15 cm in height. Several techniques were used to determine the population densities of insect species which were present. Those insects that were observed damaging the plants were collected.

The plants were vigorously shaken over a 30 × 30 cm piece of cloth to quantify population densities of stink bugs. Representative specimens were sent to Division of Entomology, Colombo Museum andto Commonwealth Institute of Entomology, London, England for identification. The cumulative means were calculated from the collections of each insect species for the experimental period.

Data were also collected for beanfly infestation at both experimental sites using the introduced and local selections. The selections with swollen and split stems with beanfly larvae inside were considered as susceptible selections and data were recorded. Yields for each selection were calcualated on the uniform basis of g/5 plants.

Experiment 2 – *Seed treatment to control beanfly infestation:*

The local mungbean variety 'ML_4' was used in this experiment. The experiment design was complete Randomized Block (CRB) with 4 replications. The insecticides monocrotophos (monocrotophos 60% W. S. C.), methomyl (*s* – methyl *N* – (methylcarbamoyloxy) thioacetimidate) 18% w/v, Sevin (1 napthylmethyl carbamate) 43.4% by wt, Baytroid(6% cyfluthrin), and aldrin (aldrin 20) 200 g/l were used as treatments with a control treatment with water.

The optimum time of soaking the seeds in insecticide solutions was determined through the method described by WIJESEKERE & ABEYTUNGA (1983). They reported an optimum time of 6 h of soaking cowpea seeds in water. Standard germination tests in petri–dishes (diameter 90 mm) were carried out using 100 seeds soaked in insecticidal treatments and were replicated 5 times. The seeds treated with insecticides were planted in polythene bags 25 × 25 cm arranged in a CRB design containing oven baked soil. The beanfly infestation level was evaluated 4 weeks after planting by uprooting the seedlings and counting the number of plants with swollen or split stems.

RESULTS AND DISCUSSION

Experiment 1 – *Identification of pests and varietal evaluation:*

The beanfly *O. phaseoli*, the pod borer *M. testulalis* and the white fly *B. tabaci* were found as major pests affecting mungbean in southern region of Sri Lanka (Table 1). The beanfly population averaged 207 insects during the experimental period and was considered the major pest. SUBASINGHE & AMARASENA (1983) reported that seedling mortality as high as 80–100% has been recorded where beanfly had not been timely controlled. Infestation began 5 days after the seeds germinated. Leaves of infested plants became pale and swollen, cracked

TABLE 1. Cumulative mean number of insects (±SE) collected from mungbean during Oct.–March 1986/1987.

Species	Class[1]	Status[2]	Mean no of insects ± SE
Melanagromyza phaseoli	L, A,	P	207.2 ± 2.3
Bemisia tabaci	N, A	P	117.6 ± 1.7
Maruca testulalis	L, A	P	58.6 ± 5.1
Nezara spp.	N, A	P	10.5 ± 2.7
Riptortus spp.	A	P	8.1 ± 1.9
Aphis caraccivora	N, A	P	—
A. gossypii	N, A	P	—
Heliothis armigera	L, A	P	13.5 ± 2.1
Anoplocnemis phasiana	A	P	2.6 ± 0.1
Chaetocnema spp.	A		2.5 ± 0.3
Spodoptera litura	L, A	P	24.5 ± 0.7
Tetrastichus spp.	A	B	2.1 ± 0.1
Antrocephalus spp.	A	B	5.3 ± 0.4
Apanteles spp.	A	B	5.1 ± 1.7
Coccinella spp.	A	B	83.1 ± 1.8

[1]L : Larva N : Nymph A: Adult
[2]P : Pest B : beneficial

or rotted stems were observed. The plants that survived the attack produced few pods many of which were empty or contained small seeds (ABUL-NASR & ASSEM, 1968). The white fly *B. tabaci* a minute homopteran that feeds on the undersides of the leaves is the vector of yellow mosaic virus disease which has posed a real problem for the cultivation of mungbean in the dry zone of Sri Lanka (WIJERATNE BANDA & FERNANDO, 1981). A mean of 117 white fly nymphs and adults were found to cause wilting and defoliation of leaves. The pod borer *M. testulalis* is a major pest of grain legumes. It was reported that close spacing which resulted in pod contact was most liable for infestation by this pest (WIJERATNE BANDA & FERNANDO, 1981). The pentatomid *Nezara* spp. was present in law numbers (10.5 ± 2.7) feeding on the tender shoots and pods. The presence of the bean aphid *A. craccivora* has been reported widely in legumes (WIJERATNE BANDA & FERNANDO, 1781). However, aphids were not observed throughout the experiment at every sampling date probably due to the prevalence of predatory Coccinellid (*Coccinella* spp.), *A. craccivora* causes crop loss as vector of various viruses that can cripple or kill the host.

From the screening germplasm experiment four selections 'VC 4281-B', 'VC 4221-B', 'VC 4290-B' and 'V 6083' showed lower incidence of beanfly damage (Table 2). The selection 'VC 4281-B' had the highest yield under low fertility conditions with lower beanfly incidence. The selections 'V-1400',

TABLE 2. Screening of mungbean germplasm for resistance/suceptibility to *O. phaseoli*[a].

Entry	Pedigree	% beanfly incidence	Yield[b]	
			low fertility	high fertility
V–1400	EG–MG–16	90	4.09	5.89
V–1948	CES 87–17	92	7.20	8.45
V–2815	M 339	90	6.60	12.29
V–3403	Utong I	90	6.21	6.84
VC–4231 B	VC 2719 A/EG–MD–6D	95	6.43	6.84
VC 4281 B	VC 1560 D/VC 1137 A	05	9.28	5.59
VC 4221 B	VC 1131 B/VC 2719 A	10	3.35	5.95
VC 4290 B	VC 2770 C/VC 2307 A	05	8.15	3.40
V 6083	OKLA 5579–8	05	7.05	4.20
MI 4	—	65	5.89	4.92
MI 5		70	6.21	5.04
Mean (127 entries)			6.89	8.76
SE			1.84	2.59
CV%			3.38	6.73

[a] total of 127 entries (120 from AVRDC and 7 local selections were tested in 1986 Maha (Oct.–Jan).

[b] Yield is calculated as g/5 repre. plants.

'V 1948', 'V 2815', 'V 3404' and 'VC 4231–B' had more than 90% beanfly incidence and were considered susceptible. The other entries had beanfly incidence in between the lowest and highest percentage with all entries recording a mean yield of 6.89 g/5 plants under low fertility and 8.76 g/5 plants under high fertility conditions. Highest levels of field resistance to beanfly were observed in selections 'V 4281–B', 'VC 4290 B', and 'V 6083'. However, it is essential to test the stability of resistance under different agronomic conditions by conducting several field experiments in different ecological regions of the country.

Very little has been reported concerning the relationship of the various plant characters and suceptibility to beanfly. A weak positive correlation between plant height and beanfly infestation was observed (Fig. 1).

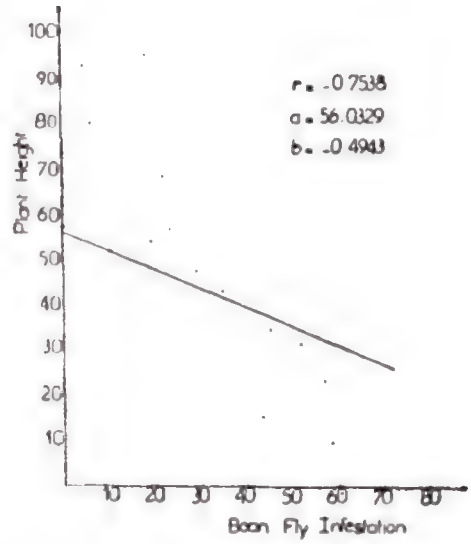


Figure 1. The relationship between plant height and beanfly infestation in selected mungbean selections.

The beanfly female lays its eggs mostly on upper leaf surface and on tender stems (BABU & RAJASEKERAN, 1981) and petioles (WALKER, 1960). The eggs hatch after 2–3 days and the larvae mine sub-epidermally through the leaves, petioles and stems of seedlings and pupate within the stem close to the ground level (WIJESEKERA & ABEYTUNGE, 1983). Therefore the only stage at which this insect can select a host plant is the adult stage. Consequently we studied infestation in relation to plant height in a wide range of mungbean germplasm and found that lesser the plant height the higher will be the infestation by beanfly.

Experiment 2 — Seed treatment with five insecticides:

The organophosphate, monocrotophos and the carbamate, Sevin gave significant control of beanfly for 4 weeks (Table 3). There were significant differences between untreated control and insecticidal treatments with aldrin, methomyl and Baytroid. The consistent good performance by monocrotophos in 1982/1983 season in controlling *O. phaseoli* in cowpea was reported by WIJESEKERA & ABEYTUNGA (1983). However, they reported that performance of carbamate, carbosulphan seed treatment was not consistent enough to make a recommendation. Thus this work with that of WIJESEKERA & ABEYETUNGE (1983) recommends the use of monocrotophos seed treatment to control beanfly in the plants in the vulnerable stage. This is important because hymenopteran parasites control led *O. phaseoli* to about 40% in the field (FELLOWS & AMARASENA, 1977). Thus seed treatment will enable the farmer to reduce the number of foliar sprays now recommended (WIJESEKERA & ABEYETUNGE 1983) and will also enhance the development and survival of parasites.

TABLE 3. Percentage damage due to *O. phaseoli* larvae in 4 week old mungbean seedlings (MI_4) with seeds soaked in 4 insecticidal solutions for 6 h.

Insecicide	Dosage	Per cent damage swelling stems	Seedling mortality
Organophosphate			
monocrotophos	0.66 ml	5.40 a	3.85 a
methomyl	2.07 ml	14.80 b	21.10 b
Carbamate			
Sevin	0.66 ml	9.85 a	8.86 a
Cyclodiene			
aldrin	0.357 ml	22.35 b	29.40 b
Pyrethroid			
Baytroid	1.23 ml	21.35 b	27.65 b
Control		48.5 c	36.5 c

[a] Treatments in the same column followed by the same letter were not significantly different by Duncan Multiple Range Test.

TABLE 4. Percentage germination of mungbean seeds soaked for 6 h in 5 insecticidal solutions with a control treatment of water.

Treatment	Concentration in 1l of water	Percent germination [1]
monocrotophos	0.66 ml	90 a
methomyl	2.07 ml	70 b
Baythroid	1.23 ml	72 b
aldrin	0.357 ml	65 b
Sevin	0.66 ml	74 b
Control	—	70 b

[1] Treatments in the same column followed by the same letter were not significantly different by Duncans Multiple Range Test.

It was also found that seeds treated with monocrotophos gave significantly high percentage of germination (90%) than other insecticides, when seeds were soaked for 6 h. (Table 4). Therefore, the advantage of using monocrotophos and Sevin as seed treatment against the present practice of using foliar sprays is considerable to control beanfly infestation in southern region of Sri Lanka. The seed treatment with monocrotophos and Sevin which has proved to be effective, can be practised in Sri Lanka for enhancing mungbean production. SUBASINGHE & AMARASENA (1983) reported that subsistence production of grain legumes with economic constraints in using insecticides could favour the development of methods to conserve and promote biological control mechanisms. This is one method to promote the above and it is worthwhile in making further attempts.

REFERENCES

ABUL-NASR, S., & M. A. H. ASSEM (1968) Studies on the biological process of the beanfly *Melanagromyza phaseoli* (Tryon) (Diptera Agromyzidae). *Bull. Soc. Entomol.* Egypt, **52**, 259–283.

BABU, P. C. S. & B. RAJASEKARAN (1981) A note on the control of stemfly *Ophiomyia phaseoli* (Cog) on cowpea *Vigna unguiculata* (L). *Madras agric. J.*, **68** (3), 205–206.

FELLOWS, R. W. & J. AMARASENA (1977) Natural parasites of some grain legume pests in the dry zone. *Trop. Agric.*, **2**, 83.

SUBASINGHE, S. M. & C. J. AMARASENA (1983) Seasonality and control of the beanfly *Ophiomyia phaseoli* (Tryon) (Diptera : Agromyzidae) attacking grain legumes. *Trop. Agric.*, **139** 75–84.

VIGNARAJAH, N. (1978) Status of mungbean production in Sri Lanka. *Proc. First Internat. Symp. Mungbean*, Asian Vegetable Research and Development Center, 9–11.

WALKER, P. T. (1960) Insecticide studies on East African agricultural pests. III. Seed dressing for the control of the beanfly *Melanagromyza phaseoli* (Cog.) in Tanganyka. *Bull. ent. Res.*, **50**, 781–793.

WIJERATNE BANDA, P. M. & M. H. J. P. FERNANDO (1981) Some aspects of pest management in grain legumes in Sri Lanka. *Symp. Sri Lanka Assoc. Adv. Sci.*, 19 p.

WIJESEKERE, G. A. W. & K. G. W. ABEYTUNGE (1983) Seed treatment with insecticides for the control of *Ophiomyia phaseoli* (Tryon) on cowpea in Sri Lanka. *Trop. Agric.*, **139**, 43–49.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 165 to 168

REPORTS AND NEW RECORDS

A CYTOPLASMIC POLYHEDROSIS VIRUS OF PINK BORER *SESAMIA INFERENS* WLK. (NOCTUIDAE: LEPIDOPTERA)

S. EASWARAMOORTHY, G. SANTHALAKSHMI, M. SHANMUGASUNDARAM & H. DAVID
Division of Entomology, Sugarcane Breeding Institute, Coimbatore, India 641 007

(*Received* 28 *June* 1987)

A cytoplasmic polyhedrosis virus, for the first time, is reported to infect the pink borer, *Sesamia inferens* Wlk.

(*Key words* : cytoplasmic polyhedrosis virus, a new disease, pink borer, *Sesamia inferens* Wlk)

Mass rearing of pink borer, *Sesamia inferens* Wlk., (Noctuidae : Lepidoptera) on artificial diet (EASWARAMOORTHY *et al.*, 1987) is being carried out in the laboratory for the multiplication of the sugarcane shoot borer parasite, *Sturmiopsis inferens* Tns. (Tachinidae : Diptera) for the past few years. During recent years, it was observed that a large proportion of the insect culture succumbs to a disease. Microscopic examination of the body contents of dead larvae under phase contrast revealed the presence of virus particles. The electron microscopic examination confirmed the presence of cytoplasmic polyhedrosis virus (CPV) (Fig. 1). This is the first record of a CPV on *S. inferens*.

The virus particles measure from 0.8 to 1.4 μm in size with a mean of 1.1 μm. The virus infection is more in second and third instar larvae and the infected larvae become distinctly reduced in size (Fig. 2) compared to healthy larvae of the same batch. The reduction in length was to an extent of 27.4 percent. The infected larvae show deep pink colour on the dorsal surface and the midgut becomes creamy white in colour which is visible through the ventral surface. Such larvae become sluggish and respond poorly to external stimuli. The body of the dead larvae are soft and shrunken. There is 40 to 50 percent mortality of the larvae in some generations. The late instar larvae showing disease symptoms pupate, but the pupae show malformation and lack of chitin deposition on the ventral surface (Fig. 3) and adults fail to emerge from such pupae.

A suspension obtained from about 100 caterpillars collected in distilled water one year ago and freshly dead caterpillars were

TABLE 1. Mortality of pink borer larvae fed with cytoplasmic polyhedrosis virus.

Treatments	% morality	Incubation period (days)		
		Minimum	Maximum	Mean
1. Fresh virus culture-1 × 10^9 IBs g of diet	51.4	9	21	11.8
2. One year old virus culture-1 × 109 IBs g of diet	12.9	9	23	16.5
3. Control	0.0			

Publication no. 985.

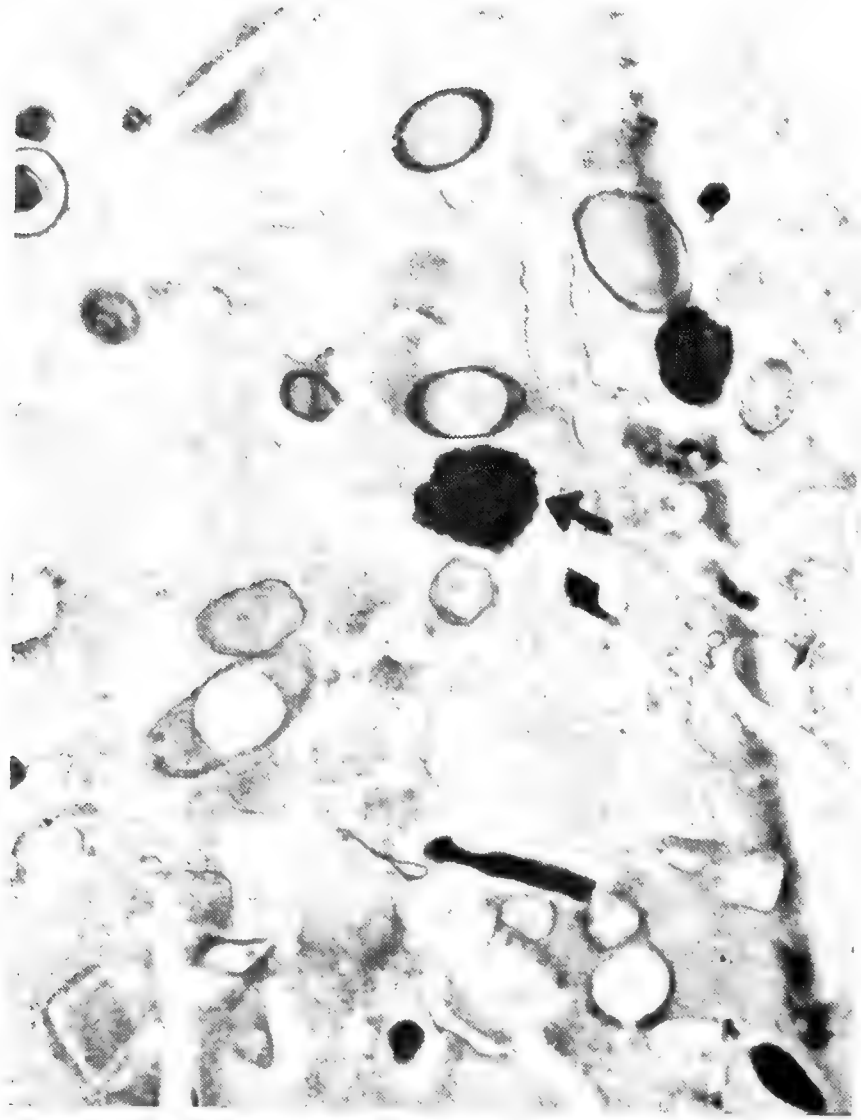


Fig. 1. Electron micrograph of CPV - Arrow indicates the virus particle

Fig. 2. Symptom of CPV infection in larva : top-infected ; bottom-healthy.

Fig. 3. Symptom of virus infection in pupa: top - infected ; bottom- healthy.

purified by differential centrifugation. The virus particles were counted under phase contrast microscope using a Petroff-Hauser and Helber counting chamber with 0.02 mm depth. After suitable dilution, the virus was added @ 1×10^9 inclusion bodies/g of diet just before solidification and stirred well. Freshly moulted second instar larvae were allowed to feed on the contaminated diet while larvae fed on normal diet served as control. The larvae were examined daily and mortality recorded. Data presented in Table 1 shows that the virus is pathogenic and caused 51.4 per cent mortality when fresh virus culture was used. The incubation period varied from 9 to 21 days. There was reduction in mortality and increase in incubation period when the virus culture stored for one year is used for infection.

The authors are grateful to Dr. K. MOHAN NAIDU, Director, Sugarcane Breeding Institute for the facilities provided and Dr. J. R. ADAMS, USDA, Maryland, for the electron micrograph.

REFERENCES

EASWARAMOORTHY, S., H. DAVID & M. SHANMUGASUNDARAM (1987) A laboratory technique for mass multiplication of pink borer *Sesamia inferens* Walker (Noctuidae : Lepidoptera). *J. ent. Res.*, (In Press).

Entomon 1989 Vol. 14 No. 1 & 2 pp. 169

BIOSTERES VANDENBOSCHI FULLAWAY - A NEW BRACONID PARASITE OF *CARPOMYIA VESUVIANA* COSTA FROM THE INDIAN DESERT

M. P. SINGH
Central Arid Zone Research Institute, Jodhpur
India 342004

Two braconid parasites, *Bracon fletcheri* and *Biosteres vandenboschi* were identified from *Carpomya vesuviana*.

(*Key words:* *Carpomyia*, braconid parasite, *Zizyphus*)

(*Received* 31 *March* 1988)

While studying the emergence pattern of *Carpomyia vesuviana* Costa (Tephritidae: Diptera) from the pupae under arid conditions of Western Rajasthan, two braconids were collected from among the emerging fruit flies at the Central Arid Zone Research Institute, Jodhpur. These were identified as *Bracon fletcheri* Silvestris and *Biosteres vandenboschi* Fullaway. The former is a well known parasite of *C. vesuviana* (Batra, 1953; Narayanan and Batra, 1960). Kahre (1923) has reported parsitization of *ber* fruit fly by *Opius* (*Biosteres*) *carpomyiae* Silv. There has not been any report of *Biosteres vandenboschi* with reference to the *ber* fruit fly from India and as such it appears to be a new record of larval /pupal parasite on *Carpomyia vesuviana*.

The level of parasitization by the braconids was, however, very low. There are chances of enhanced parasitization in the coming years looking to the ever increasing tendency of the farmers to raise *ber* (*Zizyphus mauritiana* Lamk) orchards in the desert regions.

The author wishes to express gratefulness to Dr. G. Nixon, Commonwealth Institute of Entomology, London, for the identification of the braconids.

REFERENCES

BATRA, H. N. (1953) Biology and control of *Dacus diversus* Coq. and *Carpomyia vesuviana* Costa and important notes on other fruit flies in India. *Indian J. agric.*, **23** (2), 87–112.

KHARE, J. L. (1923) Ber (*Zizyphus jujuba*) fruit and its fly pests. *Agric. Res. Instt. Pusa Bull.*, **143**, 1–16.

NARAYANAN, E. S. & H. N. BATRA (1960) *Fruit-flies and their Control.* ICAR, 68 pp.

Entomon 1989 Vol. 14 No. 1 & 2 pp. 170

NOTE ON THE INCIDENCE OF *METAPODISTIS POLYCHRYSA* MEYRICK (LEPIDOPTERA : GLYPHIPTERIGIDAE) ON SMALL CARDAMOM (*ELETTARIA CARDAMOMUM* MATON)

B. GOPAKUMAR, D. KUMARESAN & S. VARADARASAN
Indian Cardamom Research Institute, Myladumpara, Kailasanadu, Idukki District, Kerala, India 685 553

(*Received* 12 *January* 1988)

Metapodistis polychrysa **Meyrick infesting small cardamom is recorded for the first time from India.**

(*Key words:* new record, *Metapodistis polychrysa*, small cardamom)

Small cardamom (*Elettaria cardamomum* Maton) is being depredated by a host of insect pests, about 56 insect species are so far recorded as major and minor pests (NAIR, 1978; KUMARESAN *et al.*, 1987). This note pertains to the observations on *M. polychrysa* Meyrick, a defoliator recorded on cardamom for the first time.

Caterpillars of *M. polychrysa* are found feeding on the unopened leaves of cardamom in plantations in Idukki district, Kerala. They enter the leaves making a hole near the middle of unopened leaves and usually feed on one half of the leaf lamina as well as part of the mid-rib from the point of entry to the leaf tip. Due to the damage caused on the mid-rib, the leaf, after it opens, hangs downwards from the point of entry of the caterpillar. Ten percent of leaves on infested plants is thus damaged.

The caterpillar is pale green with a smooth body, measuring 1 cm long when fully grown. Head and the last abdominal segment bear large black dots, dorsally. Larval period lasts for 12–15 days. Pupation takes place inside a thin cocoon. It remains in the pupal stage for 15–18 days. The adult is a small shiny blackish brown moth, with two small golden stripes on the wings. The insect completes its life cycle in 30–35 days.

The authors express their gratitude to Dr. K. TUCKAND and Dr. G. S. ROBINSON, Commonwealth Institute of Entomology, London, for confirming the identity of the insect. Thanks are due to Dr. R. NAIDU, Director, Indian Cardamom Research Institute, Myaladumpara tor encouragement.

REFERENCES

KUMARESAN, D., S. VARADARASAN & B. GOPAKUMAR (1987) Review and current status of research on insect pest control in cardamom cropping systems. Proc. workshop on Insect Pest Management on Coffee, Tea and Cardamom Cropping systems, CCRI, Balehenoor. *J. Coffee Res.* (suppl.), **17**, 84–87.

NAIR. M. R. G. K. (1978) *A Monograph on Crop Pests of Kerala and their Control.* Kerala Agricultural University, Kerala, 162 pp.

PROFESSOR M. L. ROONWAL

ON HIS EIGHTIETH BIRTHDAY

On 20th December 1988, a distinguished gathering of educationists, scientists, administrators, young scholars, students, admirers, co-workers and well-wishers felicitated PROFESSOR M. L. ROONWAL on his eightieth birthday at a gathering in Jodhpur.

Professor Roonwal is renowned as a great Zoologist the like of whom is indeed a rarity. A remarkably unassuming modest gentleman, immensely devoted to his research work, a fount of knowledge and an extremely amiable teacher, Professor Roonwal has cruised his innings with tremendous discipline and consistent quiet charm in pursuing his never ending efforts towards search for more knowledge. I have had the privilege of being Prof. Roonwal's student and of being his colleague. I find and experience tremendous dignity and inspiration in Professor Roonwal's punctual walk to his office and in his devoted sittings while he is at work. He has been a scientist without superficialities.

Professor Roonwal was born in Jodhpur on 18th September 1908. He matriculated from the erstwhile Darbar High School. He is an M. Sc. Honours from the Lucknow University and obtained his Ph.D. and Sc. D. from Cambridge, and was associated with the Imperial Council of Agricultural Research. He was Professor of Zoology at Government College, Ajmer, and was Assistant Locust Entomologist at the Locust Field Research Station at Pasni,

now in Pakistan. He was Forest Entomologits at Forest Research Institute, Dehra Dun and was Director of Zoological Survey of India, Calcutta, Head of the Department of Zoology in Jodhpur University and took over as Vice-Chancellor of Jodhpur University. After completing his tenure as Vice-Chancellor, Professor Roonwal became Emeritus Scientist, CSIR at Zoological Survey of India, Jodhpur. Professor Roonwal was earlier Major in the 15th Punjab Regiment, during the Second World War and he saw action in South-East Asia and was awarded the Burma Star and the War Medal for his distinguished scientific service.

Professor Roonwal travelled extensively in Europe, U. S. A., Africa, South America and many parts of Asia. He has been associated with UNESCO and Food and Agricultural Organisation, and was President of the Zoology and Entomology Section of the Indian Science Congress in 1949. He was awarded the Tata Gold Medal of the Zoological Society of India in 1956; he became President and Foundation Fellow of the same Society from 1957–1960; he was elected Fellow of the National Institute of Sciences of India and was President and Fellow of the Rajasthan Academy of Sciences in 1951. He was a Member of the Advisory Council of the Bombay Natural History Society and was President of the Indian Association of Systematic Zoologists, Calcutta. Professor Roonwal was the President of All India Congress of Zoology, Lucknow in 1959. He was Honorary Fellow of the Indian Academy of Zoology, Lucknow and of the Cecidological Society of India and Honorary Member of the All Union Entomological Society of the Soviet Academy of Sciences, Leningrad and Honorary Member of the Entomological Society of India. He received the Har Swarup Memorial Lecture Award of the Indian National Science Academy and was the President of the Indian National Committee of International Society of Tropical Ecology. Professor Roonwal continued unabated his dedicated research and learning with consistent zeal. He was Secretary General of Indian Board for Wildlife and was Member of the Indian Historical Records Commission; Chairman, Managing Committee of the Indian Museum, Calcutta; Treasurer of the India Museum, Member of the Board of Trustees of Indian Museum; Chairman of the Entomological and Animal Pests Committee of Indian Council of Agricultural Research; Chairman of the Government of India Committee on preservation of Fauna and Flora of India; Chairman of the Termite Committee of the National Buildings Organization; Chairman of the Biological Research Committee of the Council of Scientific and Industrial Research and Founder President of Ethological Society of India.

Professor Roonwal has been working incessantly in the field of Zoology since 1930. Over this period of 50 years, he has, through his endeavour and research, contributed 400 research publications which include books and monographs both in pure and applied Zoology. His complete work has been listed in *Biography and Scientific Contributions of Professor M. L. Roonwal* Edited by Dr. R. C. Sharma, and Published jointly by the Entomological Society of India, Zoological Survey of India and the Deparment of Zoology, University of Jodhpur, in 1988. His papers include those on insect embryology, various aspects of biology, taxonomy, ecology, behaviour and control of locusts, lepidopterans, beetles, termites, grasshoppers, rodents and primates. Professor Roonwal has to his credit, a new theory now known as "Roonwal's hypothesis" on the phase characters of locusts, especially on the presence of the eye stripes and their bearing

on the population dynamics and swarming. Roonwal's work earned for him worldwide acclaim and acceptance from international scientists. Professor Roonwal has discovered scores of new species and new family of termites and he has done remarkable work on microsculpturing pattern on the wings of termites. He has recently reviewed the work on Indian rodentology. His study on ecology and behaviour of Indian Primates has been commended internationally. His book on primates of South Asia published by Harvard University Press is a rubric of scholarship and the result of devoted labour.

We took pride in felicitating a man so rich, whose knowledge is so profound and a man so humble and worthy of his knowledge as Professor Roonwal. We salute him in humility and with deep sense of respect for his contribution to science and society and compliment him on his 80th birthday. A person like Professor Roonwal never retires. He will indeed keep on working, inspiring us to emulate him. We wish him well and pray that he will see many delightful tomorrows and that Providence will grant him good health and good cheer always.

"Plod on inspiring soul
For somewhere
Over the edge of the dawn
The Sun is surely shining"

R. C. SHARMA

Statement of ownership and other particulars about *Entomon*
(Form IV, Rule 8 of Registration of Newspapers (Central) Rules 1956)

1.	Place of publication	Trivandrum
2.	Periodicity of publication	Quarterly
3.	Printer's name, nationality and address:	V. K. Kesava Prabhu, Indian Department of Zoology University of Kerala, Kariavattom Trivandrum 695 581
4.	Publishers' name, nationality and address:	—do—
5.	Editor's name, nationality and address:	—do—
6.	Name and address of the individual who owns the newspaper:	Association for Advancement of Entomology, Department of Zoology, University of Kerala, Kariavattom, Trivandrum 695 581.

I, V. K. Kesava Prabhu, hereby declare that the particulars given above are true to the best of my knowledge and belief.

Sd/-
Dr. V. K. Kesava Prabhu
Publisher, Entomon,

Trivandrum,
30-6-1989

ANNOUNCEMENTS

I. INSTITUTE OF EUROPEAN LANGUAGES

a. **Translation service for Research workers:-**

The Institute undertakes translation of research articles in important European languages like French, Spanish, Italian, German and Russian, into English, and translation of English Abstracts into any of the above languages. The Panel of Consultants include specialists trained abroad. Service is quick and translation authoritative.

Tariffs:

Translation into English: Rs. 40/– per typed page. From English to other languages: Rs. 80/– per typed page. For half-page work (minimum acceptd): 50% of above tariff.

b. **Advances in biological control research in India:**

Proceedings of the First National Seminar on Entomophagous Insects and other Arthropods and their Potential in Biological Contol, Ed. K. J. Joseph and U. C. Abdurahiman Calicut, 1985, 258 pp., and published by Prof. K. J. Joseph: contains contributions by 38 specialists; only a few more copies available.

	India	*Abroad* (*Air Mail*)
Price (including postage):	Rs. 120/–	U. S. $15/–

Orders executed against advance payment only.
For your requirements, contact: The Director, Institute of European Languages, 180, Hill Gardens, Kuttanellur, Trichur–680 014, Kerala, India.

II. RESEARCH AND DEVELOPMENT FUNDING SCHEMES OF CENTRAL GOVERNMENT DEPARTMENTS AND AGENCIES

A very useful booklet entitled *Research & Development Funding Schemes of Central Government Departments and Agencies,* providing details of various R & D funding schemes and other related information in sufficient detail, has been compiled and published by Information Management Division, Ministry of Science & Technology, New Mehrauli Road, New Delhi 110016. The booklet may be had from the Director of the Information Management Division.

III. INTERNATIONAL CONGRESS OF COLEOPTEROLOGY

International Congress of Coleopterology is proposed to be held from 18–23 September 1989, in University of Barcelona. Further details may be had from Dr. Tomas Yelamos, Secretary, International Congress of Coleopterology, Department de Biologia Animal (Invertebrados), Facultad de Biologia, Universidad de Barcelona, Avda. Diagonal. 645, 08028 Barcelona, Spain.

INFORMATION TO CONTRIBUTORS

Scope: ENTOMON will accept original articles (but not reviews) arising from studies on insects, arachnids and myriapods. Articles on plant breeding against insect resistance and those purely on insecticide residue analysis etc., will not be considered. Papers purely on morphological, histological or anatomical nature based on light microscopy will not be considered though those on systematics are acceptable.

General: Manuscripts submitted for publication in the journal should not have been published or submitted for publication elsewhere. Manuscripts in *duplicate in all respects including figures,* must be sent by *Registered mail* to the *Managing Editor ENTOMON, Department of Zoology, University of Kerala, Kariavattom, Trivandrum, India* 695581. *Authors need not necessarily be members of the Association for Advancement of Entomology.*

Articles should be in English only and may be either *Brief Communications* not exceeding two printed pages, or *Papers* normally not exceeding ten printed pages. *Reports and New Records* not exceeding a column, as well as biographical notes, *Announcements* of Seminars/Symposia and other items of entomological interest etc., will also be accepeted for publication. Books for Review may also be sent to the Managing Editor.

While preparing the manuscript, the authors should consult a recent issue of the journal and follow its style closely.

Articles should be neatly typed in *double space*, including *References, Legend, Tables, Abstract* and *Foot notes.* This is essential to facilitate editorial work. Single spacing should be completely avoided. Never underline, *unless* italics is intended (eg. generic and specific names; name of journals etc.). Type only on one side of good quality *bond paper,* leaving sufficient margin.

Tables should be given on sheets separate from the text.

Illustrations when desirable, should accompany the script separately. Reference to the illustrations provided should invariably be made in the text at relevant places, and they should be always accompanied by legend, typed on separate sheets and not on figures themselves. Line drawings (original India ink drawings, one of the copies may however be a good photocopy) and photographs (no photocopies) should be consecutively *numbered* together *serially* in Arabic numerals without distinction between drawings and photographs (ie., as: Figs. 1, 2, 3, 4, etc., and *not* as: Figs. 1a, 1b, 2a, 2b or a, b, c, d. etc). Photographs should as far as possible be organised and mounted in the form of plates. Blocks upto an equivalent of one full page size are allowed free of cost. However, additional blocks will be fully charged for. Authors are advised to keep the illustrations to the minimum and carefully plan their illustrations so as to occupy minimum space and permit sufficient reduction. Too small lettering in the figures should be avoided. Strict adherence to the above instructions will facilitate early publication of accepted articles.

Reprints: The present policy is to supply 50 *reprints gratis.* Additional reprints required may be purchased. Order for additional reprints will have to be placed as soon as the paper is accepted for publication in the journal. Table showing the cost of reprints will be supplied to authors when acceptance of the article is communicated.

AUTHOR INDEX

(*Continued from cover page* 4)

Reg. No. R. N. 29386/76

(*Continued from cover page* 1)

(*Continued on cover page* 3)

Published by V. K. K. Prabhu and Printed at St. Joseph's Press, Trivandrum 695014
for the Association for Advancement of Entomology